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The Age of Power

I SUPPOSE that man got his first start over the other animals in his struggle with his environment when he learned to walk upright. This left his hands free for other purposes than propulsion.

And then he found that he could do things by the use of implements that he could not do with his unaided hands. With a rock or a club he could deliver a more powerful blow. With a pointed stone or a sharp bone or shell he could perform many helpful operations. The stone and the club were combined and he had the hammer and the ax. He became a user of tools.

And after a while he learned to supplement his own muscular effort by power derived from other sources. The sail helped out the paddle or the oar. He taught animals to work for him. He recognized the power in rushing and falling water and contrived devices to adapt it to lightening his own labor.

But the greatest lift was when he learned to use fire. It is a far cry from the day when the savage huddled about the rude hearth of which he had learned only the simplest uses to the present, when in this country alone 600,000,000 tons of coal, 400,000,000 barrels of oil and nobody knows how much wood and other fuels are burned each year to supply the growing needs of the race.

Think what his use of fire has meant to man. Without it he would be confined to a narrow portion of the earth's surface. It has extended his available food supply and warded off disease and pestilence; it has made possible the smelting and working of metals, the making of pottery, lime, cement, rubber, many of the materials of common and exceptional use. And most of all, it has made possible this age of power in which almost every movement that one makes from turning on his bath in the morning to turning out his light at night has behind it a manifestation of power, usually produced from fuel.

The census of 1869 showed 0.6 horsepower available per workman in the factories of this country. The census just completed shows 3.27. This does not take into account the power consumed by the railways, mines, office buildings, hotels, electric lighting, automobiles, steamships, etc.

The cave man and the savage made little draft upon the energy resources of the world for their simple needs. In growing vegetation the earth quickly absorbed from the sun and the radiant heavens more energy than they used either in burning fuel as fire or in the food that they consumed.

It was a significant date in the history of the earth when the energy requirements of the race exceeded the rate at which energy can be absorbed by the planet in forms convertible to human use.

We are living upon the accumulations of the past. Our age of power is motivated, not by the energy absorbed from day to day or from year to year, but by the energy absorbed ages ago and stored as coal and oil and gas in the bowels of the earth.

Measured by the large scale upon which the planet's history must be reviewed, how long will this age of fuel-produced power endure and what is to succeed it?

In the present artificial shortage of fuel we may get a close-up view of some of the consequences of its exhaustion.

F. R. Low

Heat Balance and Electrical Equipment in the Gennevilliers Station

By R. H. ANDREWS

THE general description, in the August 1 issue of *Power*, of the new Gennevilliers Station of Paris, France, made only incidental mention of the electrical equipment and the means for maintaining heat balance. Before taking up these subjects in greater detail, it may be well to review briefly a few of the more important points brought out in the former article.

The present capacity of the Gennevilliers plant is 200,000 kw. in five units of 40,000 kw. maximum continuous capacity. Each of these has a maximum two-hour overload capacity of 45,000 kw. The ultimate plant will contain eight generating units, giving a total capacity of 320,000 kw. Steam at the throttle has a gage pressure of 313 lb. and is superheated 280 deg. F., giving a total temperature of 705 deg. During normal operation all the auxiliaries, except the boiler-feed pumps, are electrically driven. In the present installation steam is produced by five Stirling-type boilers (22,600 sq.ft.) double-fired with underfeed stokers, and ten Babcock & Wilcox-type, 14,300-sq.ft. boilers single-fired with chain-grate stokers. Other features of the boiler room are Pratt convergent-divergent stacks, commonly known as "venturi-type" stacks in this country, steel-tube economizers and air preheaters.

IN CONNECTION with the electrical equipment and heat balance of this station, the following features are of particular interest: The cooling of the generators by air moving in a closed circuit with provision for use of this waste heat in the first stage of feed water heating; high-tension switchhouse equivalent to an American outdoor switchyard inclosed in a remarkably light reinforced concrete structure; all auxiliaries electrically driven from station buses fed by the main bus, except for the boiler-feed pumps, which are steam-turbine driven; feed water successively heated by generator-cooling air and the oil coolers, steam bled from eighth stage of turbines, also bled from seventh stage of turbines, exhaust steam from boiler feed pumps, steel-tube economizers. The stage bleeding and the use of air preheaters in the boilers, as described in the previous article, are the features of outstanding interest to American engineers.

Turning now to the electrical equipment of the Gennevilliers Station, the generators produce three-phase 50-cycle energy at 6,000 volts. Their full-load capacity is 40,000 kw. at 80 per cent power factor. The winding reactance is exceptionally high, the voltage rise from full-load to no load on 80 per cent power factor being 50 per cent.

One of the points of exceptional interest in this plant is the cooling system of these generators. They are air-cooled, but instead of taking air from the outside and filtering and washing several tons of it per hour, a small quantity of air—possibly 150 or 200 lb.—is used in a closed circuit. After passing through the generator, it is cooled in a surface cooler placed in the generator foundations, in a position similar to that of the condenser under the turbine. The cooling medium is mainly the condensate from the turbine condenser, so that the larger part of the losses in the generator are recovered and returned to the boiler. The conclusion should not be drawn that the generator loss is of no consequence, since it is returned to the feed water. It must be remembered that each B.t.u. of generator loss requires practically five B.t.u. at the boiler to replace it, so that, roughly speaking, the return of all the generator losses to the feed water only "saves" about one-fifth of these losses, as far as the station as a whole is concerned.

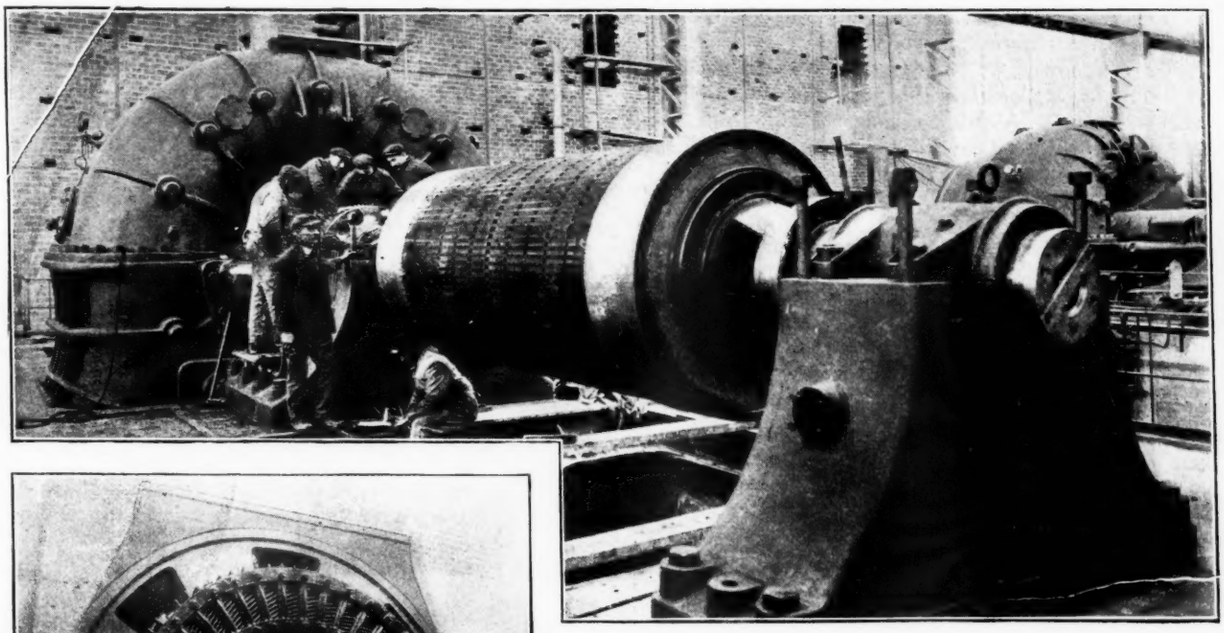
The tubular structure through which the water circulates is built up in sections, so that with suitable valves the cooling may be accomplished partly with condensate and partly with raw water that is afterward used for boiler makeup. The last passes are reserved for the raw water in order to cool the air as much as possible below the temperature of the condensate.

An ingenious device is also used on these generators to avoid the danger of overheating at light loads; for the weight of condensate available for cooling decreases with the load more rapidly than the total generator losses, on account of the constant losses. An automatic valve is therefore provided which, under light loads, returns a certain proportion of the condensate leaving the cooler to the condenser. This body of water circulating between the condenser and the cooler would have little cooling effect were it not that it increases the velocity of the water through the apparatus and therefore the activity of heat transfer between the air and the water.

The advantages of using cooling air in a closed system over the old system are many. It reduces the fire risk, for the actual weight of air available to feed an internal fire in the machine is small and would be rapidly consumed. It does away with the expense of washing and filtering the large volume of air used in the open-circuit system. The closed circuit might also eliminate the long and bulky ventilating ducts that have always been one of the troublesome problems of the designer, but in Gennevilliers it has been considered advisable to provide an emergency cooling system, by means of a large duct or gallery communicating with the outside of the plant through an air filter.

In connection with the fire risk the designers of Gennevilliers are not content with the reduction of this risk and are planning to eliminate it entirely by circulating pure nitrogen through the machines.

The low-tension bus connection between the generators has been omitted in the Gennevilliers plant, as in some other modern stations. Each generator is connected directly to a bank of three single-phase 6,000- to 60,000-volt step-up transformers. There is not even a disconnecting switch between the generator and the



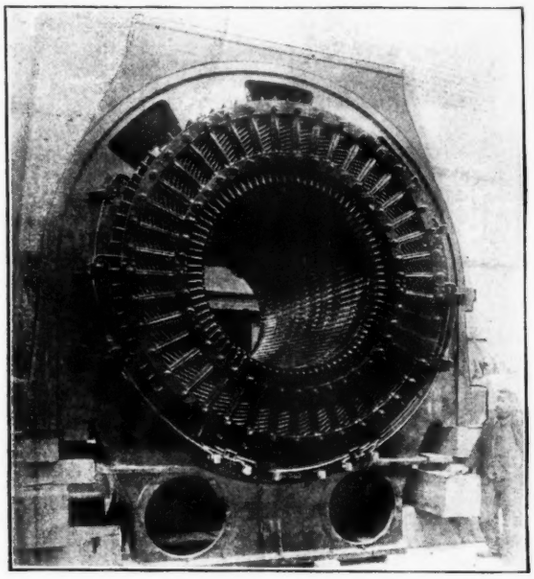
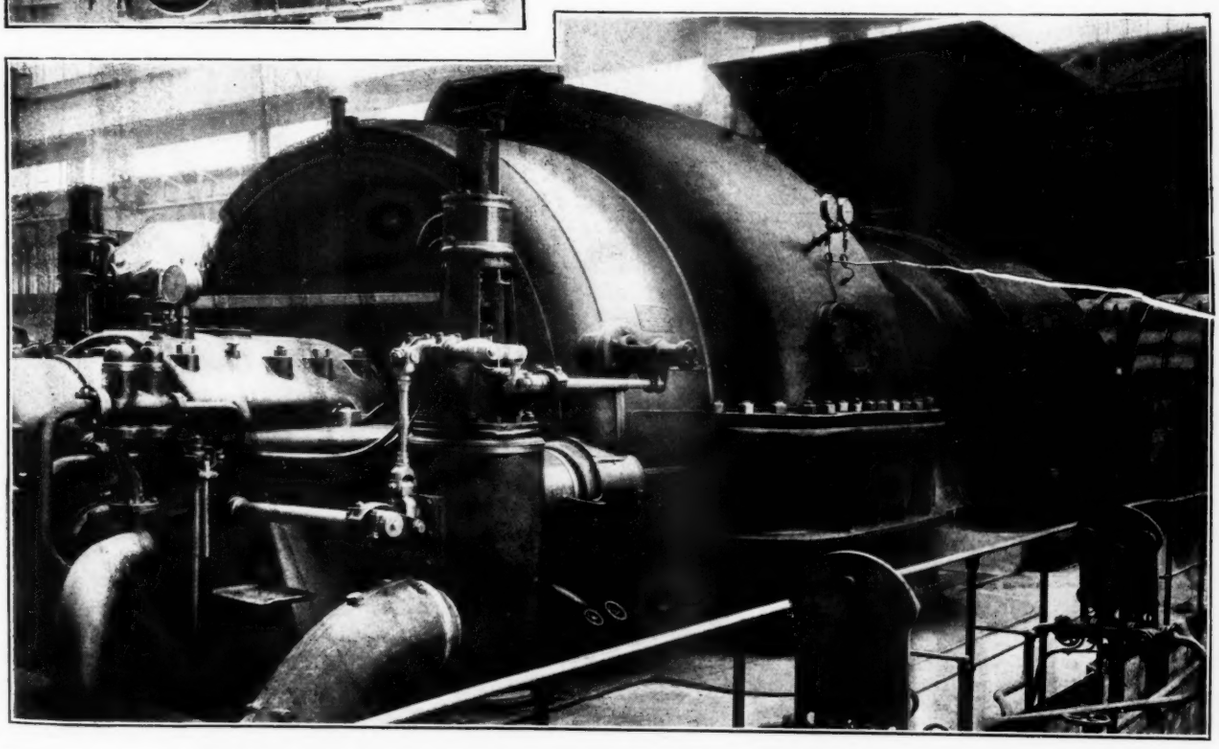


FIG. 1 (ABOVE). COUPLING TURBINE AND GENERATOR OF ONE OF THE 40,000-KW. UNITS. THE PRESENT INSTALLATION COMPRISES FIVE SUCH UNITS. THERE WILL BE EIGHT IN THE ULTIMATE PLANT, GIVING IT A TOTAL CAPACITY OF 320,000 KW.

FIG. 2 (LEFT). VIEW OF THE GENERATOR STATOR, SHOWING METHOD OF BRACING WINDINGS

FIG. 3 (BELOW). WARMING UP NO. 2 UNIT BEFORE STARTING UP



transformers. The current and potential transformers are connected to the generator leads and mounted in a gallery beneath the turbine-room floor.

The arrangement of the step-up transformers is a good example of the care that has been given to the details of design in this station. Each transformer stands in a reinforced-concrete cell, completely inclosed and closed at the top by a heavily reinforced slab. A

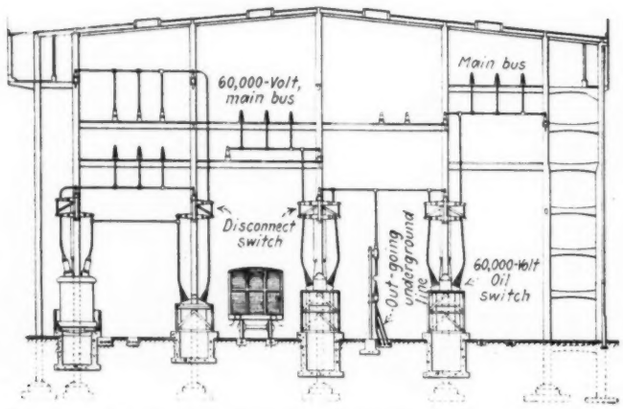


FIG. 4. THE HIGH-TENSION (60,000-VOLT) SWITCHHOUSE

This is a complete innovation as far as French practice is concerned. It is equivalent to an American outdoor switchyard inclosed in a light reinforced-concrete structure.

40-ton crane is provided by means of which this slab can be raised and the transformers lifted out of the cell for repairs.

The transformers are water-cooled, the piping, valves, temperature recorders and oil gages being placed in an operating passage running the whole length of the plant along the transformer cells. Beneath each cell is an oil pit of sufficient capacity to hold all the oil in the transformer in case of rupture of the tank. A special ventilating duct runs under the operating passage, communicating with all the pits, for the purpose of carrying off any smoke or fumes from burning oil, that they may not escape into the station in case of trouble.

HIGH-TENSION SWITCHHOUSE

The high-tension switchhouse, as shown in Fig. 4, is a complete innovation, as far as French practice is concerned. It can best be described as an American outdoor switchboard inclosed in a remarkably light reinforced-concrete structure. The conductor spacings —about 4 ft. 3 in.,—are less than would have been used in America for an outdoor station on 60,000 volts. The high-tension connections for two units are shown in Fig. 5. There are two main buses and one transfer bus. Each generator occupies one bus section with three feeders. The switching equipment, as well as the main transformers, is standard General Electric material.

The generator oil switches are controlled by two sets of differential relays, one protecting the generator windings, the other the transformers and cables up to the oil switches. The outgoing underground feeders are also protected by differential relays. Each oil switch is set over a concrete pit the object of which is to receive the oil in case of rupture of the tank, and extinguish it if it is burning.

An interesting electrical feature of this plant is that all the feeders are underground cables. No cable having ever been built for voltages higher than 35,000, it was decided not to try to build a three-conductor cable, but to use three single-conductor cables, laid together in a concrete trough.

The small station auxiliaries are driven by 220-volt three-phase motors, the larger ones by 3,000-volt three-phase motors, with the exception of the forced- and induced-draft fans, the stokers and the coal-handling equipment, which are driven by 500-volt direct-current motors. All this auxiliary power comes, directly or indirectly, from duplicate 3,000-volt station buses, fed from the main 60,000-volt bus by any one of three banks of 60,000- to 3,000-volt step-down transformers. The 500-volt direct current is supplied by four synchronous converters and 3,000- to 375-volt step-down transformers. A storage battery provides additional security for the direct-current drive. The 220-volt three-phase motors and the 125-volt lighting circuits are supplied by 3,000- to 220-127-volt transformers. The battery-charging set is driven by a 220-volt induction motor.

As an emergency supply for the auxiliaries, two 3,000-kw. 3,000-volt 3,000-r.p.m. house turbines are being installed. However, it is expected that these will be used to feed the station buses only during the night or at times of very low loads, when only one main unit

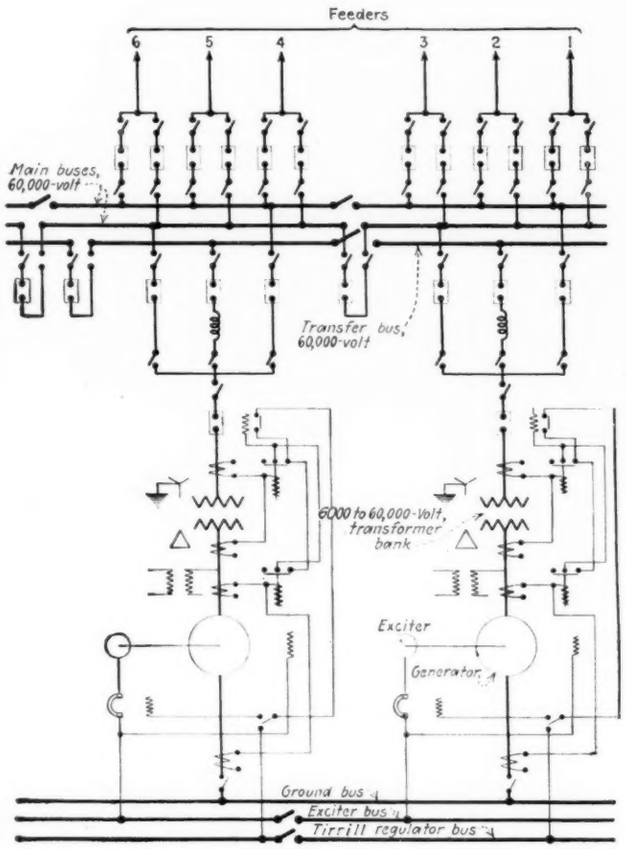


FIG. 5. ONE-LINE DIAGRAM OF HIGH-TENSION CONNECTIONS FOR TWO MAIN UNITS

is in service. At other times the chance of the whole station "going dead" is considered sufficiently remote to dispense with the additional protection. It must be remembered, of course, that three of the most important auxiliaries, the boiler-feed pumps, are steam-driven, so that a complete shutdown, if it should occur, would not result disastrously. Furthermore, the stor-

age battery provides an emergency drive for the boiler-room equipment and acts as a stand-by to the exciter system.

The methods used for controlling the heat balance of a steam plant are probably the most important and nearly always the most interesting features of the design. For this reason they have been reserved for the last in this article.

Much has been said and written about feed-water heating with bleeder steam and, in particular, about step-by-step heating with steam bled from successive stages of the turbine. The advantage of the first is that by this means the latent heat of the heating steam is saved and returned to the boiler instead of being lost in the cooling water. The additional advantage of step-by-step heating is that as much work as possible is obtained from the steam before it is used for heating.

To better emphasize the progress marked by the Gennevilliers station in feed-water heating, a brief consideration of the systems of heat-balance control of three other plants already mentioned in the previous article will prove interesting.

Delaware: Part of the auxiliaries are electrically driven. The feed water is heated, as in the older plants, with the exhaust from the steam-driven auxiliaries. In order to avoid any excess of exhaust steam, however, several large auxiliaries are equipped with duplex drive—electric motor and steam turbine—and the load so adjusted between the two as to supply exactly the amount of steam required. A bleeder connection is provided on the turbine, for the purpose of feed-water heating, but it cannot be used, owing to the absence of closed heaters. It is not safe to use steam bled from a turbine in an open heater, on account of the pressure variations in the turbine casing at different loads.

Colfax: All the auxiliaries, except a few boiler-feed pumps and forced-draft fans, are electrically driven from the main bus and a house turbine tied together through a motor-generator set. The feed water is heated by the exhaust from this turbine in a barometric condenser, the temperature of the feed water being kept constant at about 205 deg. by adjusting the division of the auxiliary load between the house turbine and the main bus.

Dalmarnock: All the auxiliaries, except a few boiler-feed pumps, are electrically driven, either from a tertiary winding on the main transformers, from station transformers, or from house turbines. The feed water may first be heated in closed heaters, by low-pressure steam bled from four of the main turbines under a vacuum of about 19 in., and in three open heaters, by the exhaust from the house turbines and from the air ejectors on one of the main condensers.

Normal operation is probably as follows: When the house turbines can be dispensed with, enough steam is bled from the turbines to heat the feed water to about 150 or 155 deg. F. In the open heater receiving the exhaust from the air ejectors, it is probably further heated to about 160 deg. and given an opportunity to give up its air. If the house turbines are operated, less steam is drawn from the corresponding main turbines, and the condensate first passes through the closed, then through the open heater, where the exhaust from the house turbines will raise it to about 160 deg. and allow it to give up its air. Finally, in case of necessity, the steam-driven feed pumps are operated, and the exhaust turned into the hotwell.

Gennevilliers: All the auxiliaries are electrically driven, either by station transformers or by house turbines, except three boiler-feed pumps. The condensate first passes through the generator-air cooler and the lubricating-oil cooler. It then flows through the two closed heaters (or auxiliary condensers) in series, wherein it is first heated by steam bled from the eighth stage, then by steam from the seventh stage of the

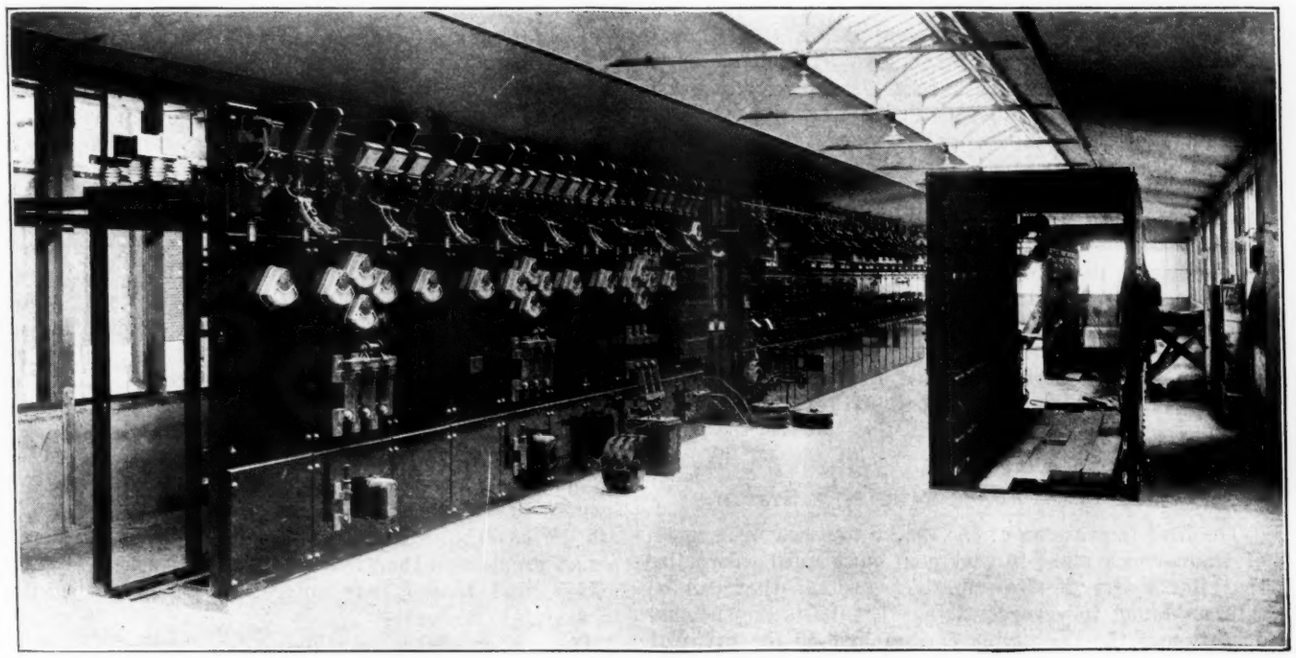


FIG. 6. STATION SERVICE 500-VOLT DIRECT-CURRENT SWITCHBOARD
The main operating board was not fully assembled

main turbine, bringing its temperature to about 184 deg. F. at full load. The condensate then goes to the condensate tank, where it receives the exhaust from the steam-driven feed pumps, by means of which it is heated to nearly 212 deg. and gets an opportunity to give up its air. The condensate tank is completely inclosed except for a vent, through which a small quantity of steam must escape continuously, as from an open heater, in order to prevent the access of air to the surface of the water. The feed next goes to the degassing filters and then to the economizers, at the temperature of approximately 210 degrees.

The Heat Balance of the Different Plants Compared

In the two American plants we have two different applications of feed-water heating with an auxiliary steam supply. These systems have in common the inherent fault of using an auxiliary supply instead of trying to save some of the latent heat of the main steam.

The only objection to the system used in the Delaware plant for controlling the amount of exhaust steam, is that the load adjustments must be made on several small units. On the other hand, it offers the maximum security for the auxiliary drive.

In Colfax we have probably the most perfect application of the principle of feed-water heating with an auxiliary steam supply. The control is simple and centralized under the switchboard operator. The amount of apparatus used is reduced to a minimum, the heating and the air removal being accomplished in the same device. For the drive of the auxiliaries it offers the simplest solution—the all-electric drive—and sufficient security, though perhaps not as high as with the duplex drive. But the inherent fault remains, that no attempt is made to cut down the loss to the main condenser.

Scotch Plant Inaugurates New System

The first impression of the feed-water heating system of Dalmarnock plant is very confusing until we realize that it consists of three distinct systems that can be intercombined in several ways. The basis for normal operation is the use of bleeder steam, and the point of prime importance is that the loss to the condenser has been tapped for feed-water heating, and that this has been accomplished under the best conditions, with low-pressure steam that has performed as much work as possible. It is the first step of a step-by-step feed-water heating system. The second step reverts to an auxiliary steam supply, partly because house turbines are considered necessary for added security in the auxiliary drive and partly so that open heaters may be used for the purpose of air removal.

In the Gennevilliers station the new feed-water heating system has taken definite shape. It may be considered as a step-by-step bleeder heating system in three steps, in which the first, instead of using steam from the ninth stage of the turbine, uses the generator and bearing losses. The house turbine has been practically discarded, being merely a stand-by, like the turbines of the duplex-driven auxiliaries. For the fourth step in the heating process we revert to the old system, using an auxiliary steam supply, the exhaust from the steam-driven boiler-feed pumps. This might have been replaced by a third heater, drawing steam from the sixth stage of the turbine; but steam drive for at least a part of the feed pumps in continuous operation is usually considered a necessary protection, and the exhaust from these pumps must be used.

An alternate solution would have been the installation of evaporators for the distillation of the boiler makeup, using the exhaust from the feed pumps, and of an extra heater drawing steam from the sixth stage of the main unit. There might have resulted a certain gain in efficiency; but against this gain would be chargeable the interest and depreciation on the cost of the third heater, and on the difference between the cost of the evaporators and the softening apparatus. Whichever way the balance leaned, the difference would probably be small, and the arrangement adopted in this plant is the simpler of the two.

Limitations of the Step-By-Step Feed-Water-Heating System

Theoretically, as far as the thermal efficiency of the turbine alone is concerned, the step-by-step heating system should be continued up to the end of the first stage. Considering the plant as a whole, this does not as yet appear practical, and it may be that this system has reached its practical limit in the Gennevilliers plant, because it is not, or at least does not seem, possible to dispense with the economizer, even though an air preheater is used to cool the flue gas. The heat capacity of the air necessary for the combustion of the coal, between the temperature limits considered practical, is hardly one-quarter of that of the feed water between condenser and boiler temperatures. For this reason some of the heat in the flue gas must be removed before it enters the preheater, in order to avoid either an excessive loss to the stack or overheating of the combustion air. This heat must be absorbed by the feed water in an economizer, and the feed must not be heated over 212 deg. F. or this will not be possible.

Whether or not it will prove possible in the future to apply the theoretical step-by-step feed-water heating system to a higher temperature limit, the Gennevilliers station has shown that this system is no longer an abstract problem in thermodynamics, but a practical realization, and that it has entered power-plant practice to stay.

The writer wishes to acknowledge the kind co-operation of Col. E. Mercier, director of the "Union d'Electricite," consulting engineers, who is responsible for the design of the plant, and of R. Gasquet, editor-in-chief of the *Revue Industrielle*, to whom he is indebted for the photographs and cuts published in this article.

The following extract from an article by Browning Robinson in the August issue of *Industrial Management* should interest the executive whose domains include a forgotten boiler room.

If we have the topic of "Combustion" led up and tied to the desk as a bald-headed subject which we are in duty bound to study, it can prove almighty dry.

The usual executive passes it up—principally because he does not grasp it, whereas there are multitudes of other items in which he has been trained, so those naturally get attention and decision first.

So far from the subject of proper combustion, how to get it and how to maintain it, being dry or dull, it is quite the contrary. The executive who realizes finally that actual money is being shoveled into the fires and that twenty or twenty-five cents can be saved out of every one of those dollars, easily, is going to wake up to the idea that this subject is a most engaging one.

Locating Faults in Direct-Current Armatures—Open-Circuits in Series and Parallel Windings*

By B. A. BRIGGS

IF A coil in an armature winding becomes open-circuited when the machine is in operation and carrying considerable load, the defect will always cause sparking at the brushes and produce one or more burnt spots on the commutator, depending upon the type of winding and the number of poles in the machine. Why this is so was explained in the articles appearing in the Oct. 4 and Nov. 1, 1921, issues. In a parallel winding there will be only one burnt spot on the commutator for each open-circuit in the winding. In a series winding a burnt spot will occur on the commutator for each pair of poles. If a coil is open-circuited in a 4-pole series winding, then 2 burned spots 180 deg. apart will occur on the commutator, and in a 6-pole machine 3 burned spots 120 deg. apart will develop. If the machine were operating under light load, the effect of the defective coil might never be noticed until some time when the load was increased and severe sparking resulted. However, it is seldom that a motor applied to industrial applications would be operating under such light-load conditions. The spark produced by an open-circuited coil can be distinguished by its vicious nature; in many cases it will appear to extend around the commutator. In 500-volt or higher-voltage machines it is likely to cause arcing-over on the commutator and to open the protection device, thus disconnecting the machine from the line.

High-resistance coils may be classed with open-circuits. This defect may be caused from two sources; one, a lead that is not well soldered to the commutator, thus causing a high-resistance connection. A second cause is one that can happen only in a winding whose coils are wound with two or more conductors in parallel. One of these conductors might become open-circuited, for example, in a coil wound with two wires in parallel. If one conductor became open-circuited, then the resistance of the path through this coil would be doubled. Since the coil must carry practically the same current through one conductor as through two, the heating of this coil will be doubled.

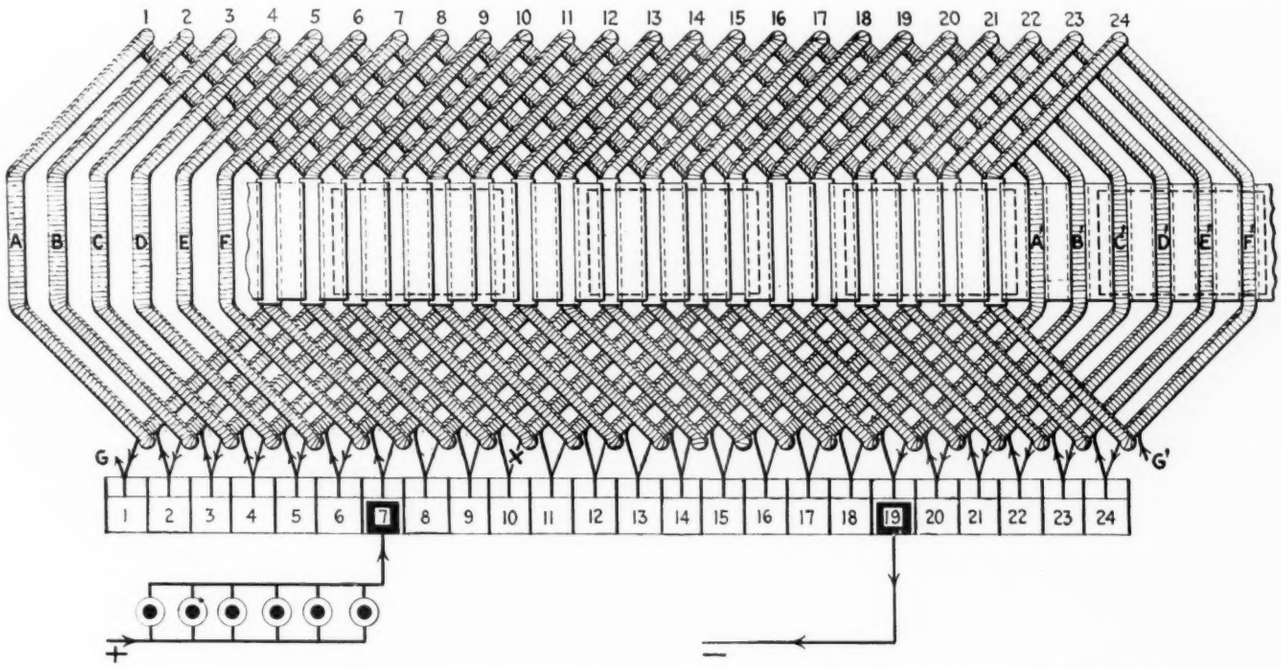


FIG. 1. PARALLEL WINDING FOR DIRECT-CURRENT ARMATURE, SHOWING OPEN CIRCUIT AT X

Although a high resistance coil may cause local heating of the commutator and sparking at the brushes, this sparking is not nearly so severe as that caused by an open-circuit. In many cases it is not sufficient to attract serious attention. However, if allowed to exist for a long enough period it will cause local black spots on the commutator. In a parallel winding only one black spot will occur, while in a series winding a spot will occur for each pair of poles. When the machine is in operation the defects can be easily located by their effects. However, when an armature is rewound, if any of the coils are making poor connections with the commutator or are open-circuited, these should be detected and repaired before putting the armature into service. These faults, like short-circuits, can be detected only with a low-reading voltmeter or a telephone receiver.

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Tests for open-circuits are similar to those for short-circuits, but the results obtained on the meter will be somewhat different. Suppose that the armature winding represented in Fig. 1 has been rewound and that there is an open-circuit in the lead from coil 10 at *X*. To test the armature, brushes are located on opposite sides of the commutator, as on segments 7 and 19, with a bank of lamps connected in series as indicated. Current can flow from segment 7 through coils 6, 5, 4, etc., to *G* then to *G'* through coils 24, 23, etc., to segment 19. However, no current can flow from segment 7, through coils 7 to 19 to segment 19, on account of the open-circuit in coil 10. Since no current can flow through coils 7 to 19, with the exception of the defective coil, no voltage exists across their terminals. Coil 10, being open-circuited, will have the full voltage existing between segments 7 and 19 impressed across its terminals. However, this voltage is always low, amounting in most cases to only one or two volts, but is sufficient to cause a millivoltmeter to be thrown violently off the scale. For this reason care should be exercised not to subject the meter to this potential unnecessarily.

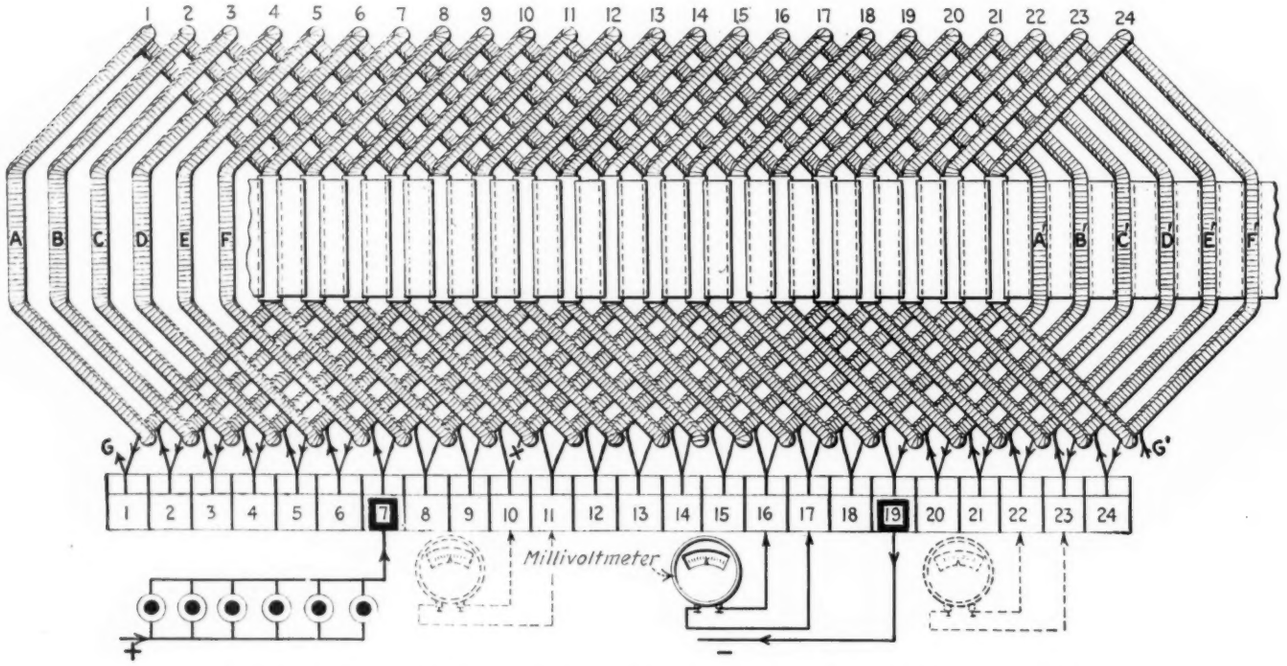


FIG. 2. METHOD OF TESTING FOR OPEN-CIRCUITS IN PARALLEL WINDINGS

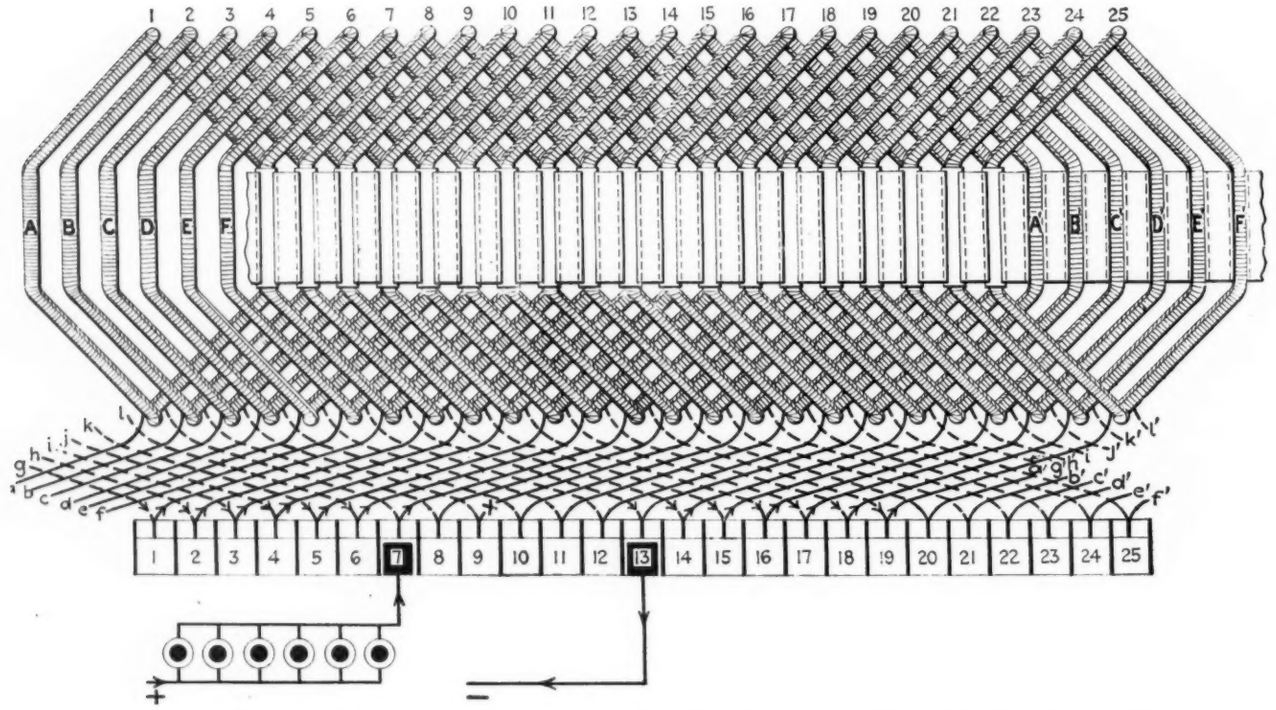


FIG. 3. SERIES WINDING FOR DIRECT-CURRENT ARMATURE, SHOWING OPEN CIRCUIT AT X

In making the test after the current has been adjusted to give a normal deflection on the meter (say three-quarter scale throw), if the meter is connected to segments 22 and 23, Fig. 2, normal deflection will result, likewise on segments 21 and 22, etc. However, if readings are taken on segments 17 and 18, 16 and 17, etc., no deflection of the needle will be obtained, since no current is flowing in the coils connected to these segments. When the meter is connected to segments 10 and 11 it bridges the open in coil 10 and current can flow from segment 7 through coils 7, 8 and 9 to segment 10, then through the meter to segment 11, through coils 11, 12, etc., to segment 19. Since the resistance of the meter is many times that of the armature coils, practically the full voltage between brushes 7 and 19 will be effective on the instrument and cause it to be thrown violently off the scale.

This violent deflection of the needle may be avoided, when it is discovered that there is an opening in the winding due to meter giving no deflection, by holding one lead of the instrument on a segment, say segment 17, and with the other lead tapping lightly segments 16, 15, etc. Now when segment 10 is touched the meter will start to deflect, but before the needle has had time to be thrown off the scale the lead should be removed from the segment. Since no reading would be obtained on segment 11, a reading obtained on segment 10 would indicate that the open-circuited coil is connected to segments 10 and 11. Another method that can be used is to connect the meter to two segments that give no deflection, say, segments 16 and 17, and then with a piece of copper wire bridge segments 16 and 15, 15 and 14, etc., until the defective coil is bridged, when the meter will give a reading somewhat lower than normal. In this case, when segments 10 and 11 are bridged, the circuit through the coils will be completed and current will flow, causing the meter to be deflected. The deflection of the instrument when segments 10 and 11 are bridged with a piece of wire shows that the defective coil is connected to these two segments.

If the open-circuit is in the coil lead, it will be easily found when the leads are disconnected from the commutator. When the defect is in the coil, it can be checked by lifting the coil leads from the segments and testing through the coil with a lamp. If the coil is open-circuited, no light will be obtained.

When a coil has a high resistance due to a poor connection to the commutator or part of a multiple-conductor coil being open, approximately normal readings will be obtained on the good coils, but on the defective coils a reading higher than normal will be obtained. In some cases, if the coil resistance is sufficiently high, the needle will be deflected off the scale. In any case, where only a reading higher than normal is obtained, a high-resistance coil may be looked for. There are conditions where high readings are obtained in combination with reverse readings that indicate cross-

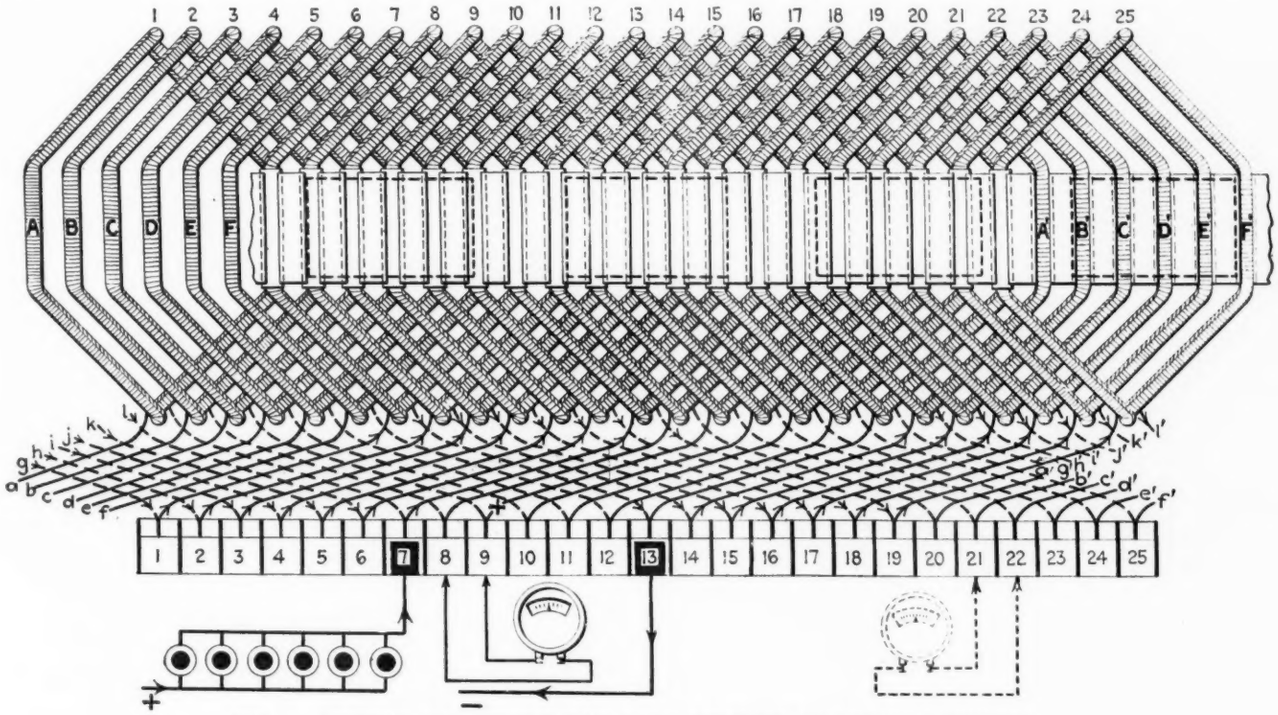


FIG. 4. METHOD OF TESTING FOR OPEN-CIRCUITS IN SERIES WINDINGS

connected coils, but this will be discussed in another article. A telephone receiver may be used in place of a low-reading voltmeter. In Fig. 2, if it were connected to segments 18 and 17, 17 and 16, etc., no click would be heard in the receiver. However, when it is connected to segments 11 and 10, the open-circuit will be bridged and a violent click will occur in the receiver, thus indicating the location of the defective coil. A high-resistance coil will give a click louder than normal.

In a series winding an open-circuit in a coil will give a dead spot on the commutator for each pair of poles. For example, in Fig. 3 assume that coil 15 is open-circuited at *X*. Now if brushes are placed on segments 7 and 13 and connected through a lamp bank to the line, current can flow through coils 13, 25, 12, 24, etc., to segment 13 and the negative side of the line, as indicated by the arrow heads. Since coil 15 is open-circuited, current cannot flow from segment 7 through

coils 1, 14, 2, 15, etc., to segment 13 and the negative side of the line. This leaves segments 8, 9, 10, 11, 12, 20, 21, 22, 23, 24 and 25 dead, so that if the meter is connected to any two of them, as in Fig. 4, no deflection will be obtained. If the meter is connected to any two of segments 1 to 6 or 14 to 19, normal deflection will be obtained if these coils are free of faults. Connecting the meter to segments 8 and 9 will bridge the open in coil 15 and the circuit will be from segment 7 through coil 1 to *a a'*, coil 14 to segment 8 through the meter to segment 9, coils 3, 16, 4, 17, 5, 18, 6, 19 and to segment 13 and the negative side of the line. This puts the meter directly in series with the coils and will result in a violent deflection off the scale. Connecting the meter to segments 8 and 9 bridged out two coils, namely 2 and 15. A similar result would be obtained by connecting the meter to segments 21 and 22. In this case the circuit is completed through coils 1, 14 and 2 to segment 21 through the meter to segment 22, then through coils 16, 4, 17, 5, 18, 6 and 19 to segment 13 and the negative side of the line. This would also give a violent deflection of the needle off the scale, as when connected to segments 8 and 9, indicating the other end of the open coil. In this case it will be noted that coils 15 and 3 are bridged out of circuit by the meter instead of coils 15 and 2. After the two points on the commutator to which the open coil connects have been located, it is then a matter of lifting the coil leads from the four segments and testing through the coils with a lamp to find the defective one. The different ways of cutting out an open coil in a series winding were described in the Oct. 1, 1921, and Feb. 17, 1922, issues.

In making the tests for the open-circuits in series winding, the meter can be protected from being subjected to the full voltage on the winding as explained for the parallel winding. In the series winding, there will be a place on the commutator, for each pair of poles, when two segments can be bridged with a piece of wire, causing the meter to deflect when connected to segments that previously were dead. For example, if the meter were connected to segments 11 and 12 in Fig. 4, it would not be deflected if coil 15 were open-circuited. However, if segments 8 and 9 or 21 and 22 are connected together temporarily with a piece of wire, the circuit will be completed through the winding and current will flow, causing the meter to give practically a normal deflection. If a high-resistance coil existed in the winding, then a deflection of the needle above normal would be obtained at two or more locations on the commutator, depending upon the number of poles. In general, a high-resistance coil is due to a poor connection to the commutator, and can be remedied by heating up the connection with a soldering iron so that the solder will flow and make a good contact. The next article will deal with the location of grounded coils with a low-reading voltmeter.

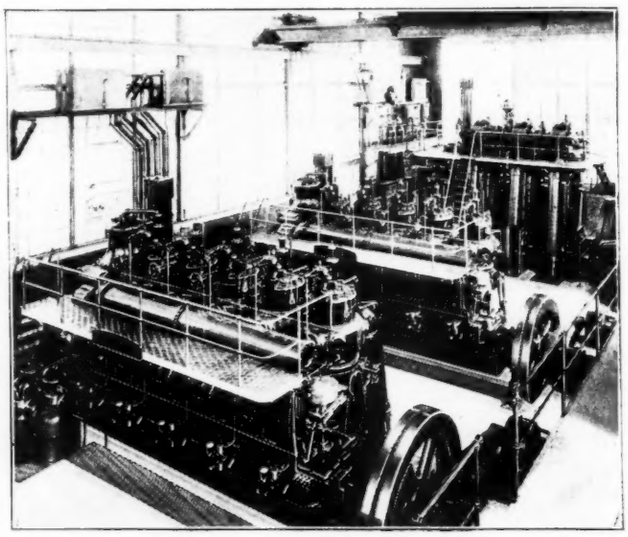
An induction motor can usually be operated on a 10 per cent higher or lower frequency than that which the machine was designed for, without seriously affecting its operation. This is also true of the voltage. However, the machine cannot be expected to operate satisfactorily on a 10 per cent increase in voltage above normal, after the frequency has been reduced 10 per cent below normal, or vice versa.

The Diesel Engine in Electric Furnace Work

The Diesel engine has been used in various industries and its economy has been proved. As the source of power for electric furnaces the oil engine has not received the attention it deserves. The general opinion has been that an oil engine of a capacity suited to the normal working demand of an electric furnace has insufficient reserve capacity to care for the furnace starting load. This is by no means correct as proved by the results of the Diesel-engine power plant of the Oklahoma Iron Works Co., Tulsa, Okla.

The power plant contains four Nordberg two-stroke-cycle Diesels. One of these units, of 750 hp. rating, is direct-connected to a two-stage 4,000-cu.ft. compressor supplying air to drive the hammers in the forge shop and other air-driven machines in different departments.

Three 550-hp. units are direct connected to 400-kva. alternators and are provided with belted exciters. The



DIESEL-ENGINE POWER PLANT

total connected electrical load is 1,535 kw.; 1,100 of this is composed of induction motors, 35 kw. is used in the lighting and 400 kw. in the electric furnaces. Fifty per cent of the motors are squirrel-cage and the remainder are slip-ring type machines.

The usual motor load ranges from 75 to 350 kw. with a daily average of 250 kw. The furnace load ranged from 150 to 600 kw. and is very unsteady during the first part of a heat.

The following are the production costs per kilowatt-hour when operating under the conditions stated:

Fuel oil, cents	0.397
Lubricating oil, cents	0.048
Labor, cents	0.329
Repairs, cents	0.004
Total production cost per kw. hr., cents	0.778

The total cost per kilowatt-hour including fixed charges is less than two cents.

Fuel oil of 25 deg. Baumé is burned, and the engines have operated satisfactorily either singly or in parallel. The lubrication consumption averages 0.2 gal. per hour per unit, there being little change in the rate from light to heavy load.

The Oil Engine of Today

By Dr. CHARLES E. LUCKE
Professor of Mechanical Engineering at Columbia University

OIL engine reliability has been steadily improving, and considerable advances have recently been made by design affecting all features of oil engine performance that are responsible for better power cost factors in addition to or through reliability, especially for the smaller and medium sizes.

Examining the oil engines themselves to bring out the relation of type or design to its competitive cost value with reference to steam, the problem of the engine may be approached most clearly by considering the four fundamental functions to be performed.

The first of these four functions is charging the cylinder with air and with fuel. It is obvious that without such a charge there can be no combustion nor work from internal combustion.

The second is the control of that fuel with the air charge in the cylinder, and the proper control of the combustion that follows. Here will be found the basis of difference between a good and a bad engine—a clean or a dirty engine—an efficient or an inefficient oil engine, one capable of using low-grade oil or not.

The third is cooling. It must be understood that the cylinder of an internal-combustion engine is a furnace. It is a furnace in which there is released *X* B.t.u. per minute, quite the same as in the furnace of a boiler, but the walls are different. It is obvious that the inclosing cylinder wall of cast iron must be so protected that in spite of a necessary high rate of heat generation it is not injured. If it be not so protected then it will be injured, and maintenance will be bad and the engine unreliable.

IN this article Dr. Lucke discusses the improvements in general design that have made the oil engine thoroughly reliable. Engineers who may have been unfavorably impressed with the earlier designs should read this discussion.

The fourth is purely mechanical. The machine parts must be right and must be rightly maintained. In this connection it must be remembered that while there are certain parts for the performance of the previous three functions—charging, combustion control and temperature control of the walls, all of which are strictly oil-engine parts—nevertheless all the rest of an oil engine is just a machine, and in that respect the same as a steam engine. Most of the parts of an oil engine are just the same as the corresponding parts of a steam engine, and they must be properly designed with regard to the rules of correct machine design, and properly maintained by correct lubrication and attention to adjustment; but, obviously, the less the adjustment needed, the more likelihood of its being made.

Each of these four functional conditions should be studied to see how each is worked out with regard to the oil engines on the market competing with one another for supremacy and all competing with steam. This sort of study, to be thorough, would take a very long time, but in the space available a few leading features bearing on reliability and power costs can be pointed out and will serve as a guide to more complete study.

There are two broad systems of air charging, the four-stroke-cycle and the two-stroke-cycle, which will now be described, on the assumption that they are understood. The four-stroke-cycle method requires the provision of an inlet valve and an exhaust valve for each cylinder, cam-opened and spring-closed, with a camshaft to carry the cams and gears to drive the camshaft from the crankshaft. It is obvious that, with a four-stroke-cycle method of charging, there is required a certain amount of mechanism which requires considerable care and attention, involving gears, cams, rollers, and rockers; these parts are multiplied by the number of cylinders, and these engines are usually multi-cylinder. As an offset to the mechanism complication of the four-stroke-cycle, the efficiency of the charging is the highest known. By high charging efficiency is meant that the cylinder can be fully charged or more nearly fully charged with air, with the least expenditure of power in so doing, than the two-stroke-cycle method. The two-stroke-cycle engine does not succeed in giving so full a charge of air to the cylinder with the same power as the four-stroke-cycle, but the mechanism required is simple.

There is quite a variety of forms of the two-stroke-cycle charging mechanism, some more simple than others, some better adapted to small sizes and others to large sizes. The simplicity resulting from the elimination in the two-stroke-cycle engine of numerous small mechanical parts found on the four-stroke-cycle engine is so great that the drop in air-charging efficiency is to be regarded as negligible in comparison with the simplicity attained. In large engines the situation is not quite the same. It will be found that in larger sizes the difference between the four-stroke-cycle engine and the two-stroke-cycle engine, as to amount of mechanism, is not so great, nor is there so much difference in cost per horsepower nor in weight per horsepower.

Fuel Charging

The fuel must be regulated to the load, and whatever charging means may be employed must necessarily involve as one element a metering device. The charging means for the fuel must provide not only for metering, but for something that will insure correctness of delivery of the metered charge to the cylinder from the combustion standpoint as to point of time in the stroke, correct time of ending, and correct rate of injection. The mechanism and devices that constitute the fuel charging are partly performing a metering and partly a timing function, and this function is closely associated with a conditioning function, whereby the oil is brought into intimate contact with the air at the right time and right rate; without this control there can be no oil engine.

Of the mechanical means of fuel charging there are two broad classes, known today by the more or less technical names of solid injection and air injection. By solid injection is meant a pump that draws in a charge of oil and at the right time delivers the metered

quantity of fuel to the cylinder. The pump is timed and the oil delivered through a spray nozzle, which is the outlet of the delivery pipe of the pump and at the inlet to the cylinder. What happens in the inlet or spray nozzle as the oil enters, is another matter. Mechanically, then, solid injection involves a timed pump of the metering type, delivering fuel oil directly through a spray nozzle to the cylinder. Anything more simple than this is not known. The other class, air spraying of the fuel oil, is the method that has always been associated with the heavy-oil Diesel engine. With this air injection method there is a spray valve in a housing and a pump that delivers the oil in metered amounts to this housing before the time it is wanted. There is also an air compressor, usually two- or three-stage, delivering air to this same housing at about 1,000 lb. pressure. At the right time a cam opens the spray valve and allows the compressed air to spray the metered oil into the cylinder. Obviously, this air spray apparatus is much more complicated than the solid injection mechanism, which latter eliminates the air compressor, the high-pressure air piping, high-pressure air storage bottles, and also the timing valve, the adjustment of which is necessarily extremely sensitive. Why then is direct solid injection, which in the interests of simplicity is so desirable, not universally used? Just because the next step of making the oil enter in quite the right way for good combustion and at the right time and rate, which is very easy by the old air-injection way, is difficult with the solid-injection method. In other words, the reason the injection of fuel by compressed air has not been superseded has been because no one knew until recently how to carry out the second step with sufficient correctness with solid injection.

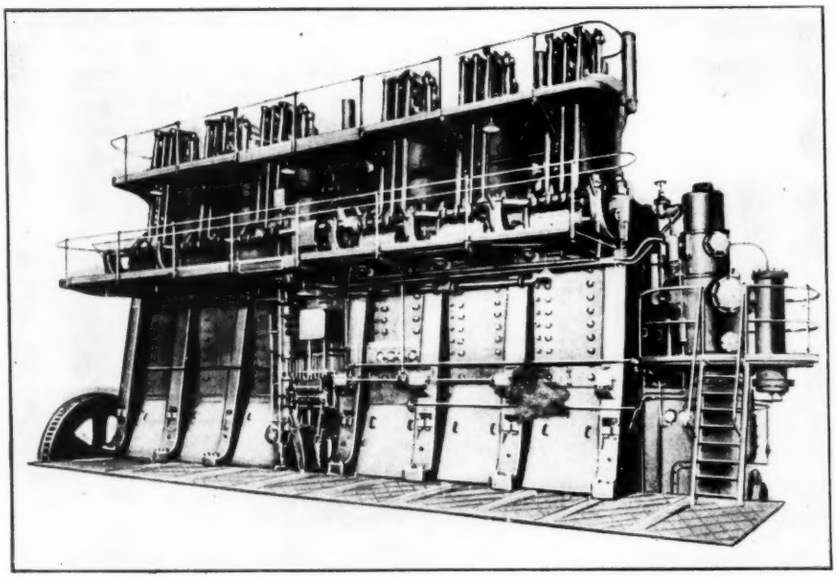


FIG. 1. TYPICAL AIR INJECTION DIESEL ENGINES

Air and Fuel Contact Control

The provisions inside the cylinder for controlling the time and rate of combustion after fuel injection into the air charge must be definitely provided for. If the cylinder be plain, that is, if the combustion space be a flat cylinder between the piston top and the cylinder head, it is a really difficult problem to get the oil to enter at one point to meet all of the air, including the air far away from the point of fuel injection. It is just as difficult a problem to get the oil to burn at a rate that will give the right cylinder pressure conditions. The correct pressure conditions are those that do not allow the pressure to rise too much or too fast and thus shock or overload the mechanism during combustion, on one hand, and on the other, do not permit the pressure to fall too much during combustion, because then the efficiency will suffer.

All engineers must realize that to meet these conditions by mechanical means is difficult; but it has been accomplished in some of the more modern designs. There are a number of different methods advocated, but one satisfactory solution involved a change of shape of combustion chamber, which change of shape has taken the place of what it was formerly regarded as a necessary but elaborate mechanism. This solution has had more to do with increased simplicity and reliability than all the other parts put together; but it is an accomplished fact worthy of study.

Cylinder Cooling

Passing now to the next function, cooling. Attention must be directed to a condition of affairs that is of the utmost importance in matters of reliability, life of parts and maintenance costs. Probably every new design of the oil engine has suffered broken cylinder heads, broken pistons, cracked cylinders or liners and broken crankshafts. It cannot be admitted that a new cylinder or head or piston or crankshaft every six months is proper maintenance. It is excessive maintenance. There is something wrong. It took some time to learn how to fix them. In some cases the design provided for better conditions of avoidance of these things than others. While there is not time to examine this situation in detail, some of the basic conditions will be pointed out, leaving to imagination and to study of existing designs to see how the knowledge of these causes might lead a designer to remedies. It is just such a study that has led to improved conditions, so that breakages are now reduced to a state that the old timers would have pronounced impossible. Continued study along these lines will surely fulfill the prediction that major breakages are going to be wholly eliminated, except in abnormal cases.

The conditions to be met are peculiar to the internal-combustion engine. Attention has been called to the fact that the interior of the cylinder is an iron wall furnace. The gases in that furnace reach the highest attainable temperature in combustion. That temperature is extremely high, something like 4,000 deg. F., and it is reached in an instant. Temperatures of that sort, especially with solid matter present, lead to most intense radiation. When fuel oil burns in air it goes through a most complicated series of chemical changes, and in the course of that series there is a time when there are particles of carbon coming out of the

hydrocarbon bond and entering the oxide bond, but which momentarily, as nascent carbon, glow like the filaments of electric lamps. Heat radiation from such a black body, to use a physical term, to the walls of the combustion chamber, varies as the difference between the fourth power of those temperatures. Consider the fourth power of something like 4,000 against the fourth power of 100 and it will be clear that there are differences of real magnitude. The result is, in effect, an almost instantaneous transfer of radiant heat from the glowing particles of fuel in the cylinder to the walls. The inner skin of the cylinder wall, in the short time of combustion (about 10 per cent of the stroke), will absorb a fairly definite fraction of all the heat generated, and this absorption cannot be stopped nor to any extent changed. Heat flows through the wall to the water jacket at a reasonably steady rate, but on the inner skin of the metal, a thin layer of perhaps 0.001 in., perhaps 0.01 in., there is absorbed a definite proportion of the heat of every fuel injection charge transmitted by radiation, and this in time feeds itself outward through the rest of the wall. The wall is divided thermally into two parts, the main part where the temperature is fairly constant, and the inner skin whose temperature is shooting up at every explosion and then falling. It is obvious from any consideration of stresses that the skin is trying all the time to tear itself away from the main body of the metal, and if the cylinder is improperly designed, cracks will eventually appear. It is clear that the thicker the wall the greater the difference between the temperature on the inner and outer skins, so that the design must provide for the expansion of the metal. It is well known that the greater the rate of heat generation per square foot of wall, the higher will be the mean temperature, and more heat must be stored in the skin that is receiving the radiant heat. The lower the speed for a given rate of heat generation per minute, the more heat must be charged to the skin per stroke, and other things being equal, there develops a greater tendency toward cracks with slow than with high speeds.

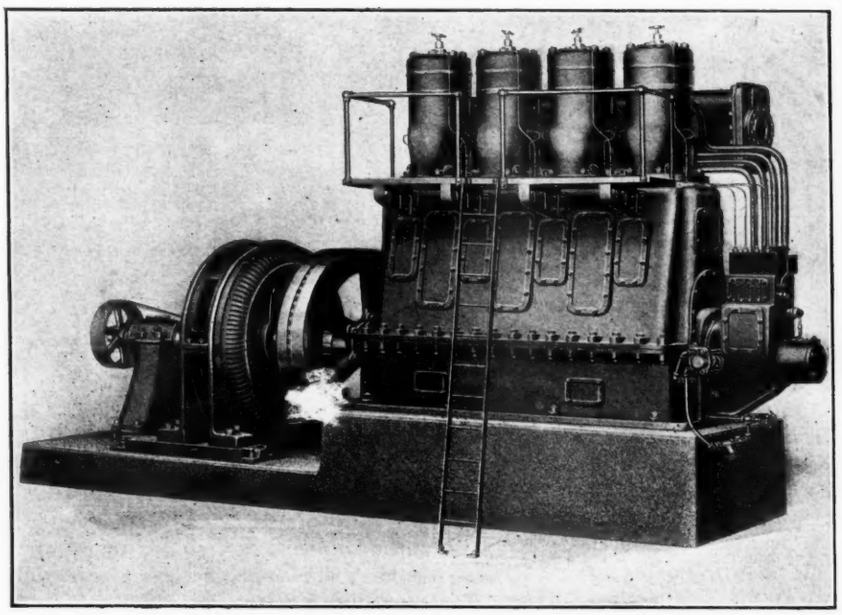


FIG. 2. SOLID-INJECTION TWO-STROKE-CYCLE OIL ENGINE

What these heat rates are is somewhat interesting to note from the following figures. The Liberty aircraft engine develops a large amount of heat in a small high-speed cylinder. Each cylinder, which is 5 in. dia. and 7 in. strike, develops 33⅓ hp. when operating at 1,625 r.p.m. Burning ½ lb. of gasoline per brake-horsepower-hour, it is generating 658,000 B.t.u. per hour per square foot of combustion chamber walls. A definite fraction of that comes through the metal, after temporary storage in the inner skin. The whole wall is only about ⅛ in. thick. A German submarine Diesel engine, 14 in. x 14 in., generates 674,000 B.t.u. per hour per square foot in a much thicker cylinder. This rate is almost identical to that of the Liberty motor, and both are recognized as being about the limit of attainment. A big motorship Diesel engine of the low-speed long-stroke type, 29 in. x 46 in., 120 revolutions, calls for only 178,000 B.t.u. per sq.ft. per hour. This is very much less than in the other cases just cited but the cylinder walls are much thicker. These rates are all high and all are near their respective limits in proportion to service conditions. Failure to recognize these heat-generating factors, which are direct measures of the tendency to burn or crack heads, pistons and cylinders is responsible for the old faults. Recognition of this situation is now growing and the remedies to be incorporated in designs pretty well understood, studied and applied by designers. When the heat-generating limitations are recognized, and walls designed in proper thickness, symmetry of form and of proper materials, breakages that were the cause of high maintenance cost and charges of unreliability in the past, are going to be swept away, if they have not been already. Finally, on the machine-design features of the engine, the features not strictly oil engine, what may be said? Probably the first and most obvious point is that, other things being equal, the engine with the greater number of parts, especially moving parts, is bound to require more attention than the one that has a lesser number.

Of course there must be some limitations as to kind of parts, it being admitted that pins give less trouble than cams, valve tappets, and gears. Next in this connection, as the matter of general arrangement, may we say with any assurance of justice that there is any great advantage in vertically arranged cylinders as compared with horizontal? Probably not in either case. Both the horizontal and the vertical, the single and the multiple can be made, if made right, to give good and reliable service. There are, however, some factors of each arrangement as to adaptability to a given service condition.

By things of the sort discussed, which could be expanded to fill volumes, the maintenance of oil engines is being generally reduced. With the lowered attendance and maintenance costs the oil engine has become a most attractive prime mover.

Transformation of the Indicator Diagram into the T-N Diagram

MANY engineers are familiar with the indicator and are quite adept in interpreting the diagram obtained from the engine. While the indicator diagram is useful in revealing defects in valve setting, etc., it is of little service if the action of the steam in the cylinder is to be studied. For this reason the *P-V* diagram, so called since the vertical ordinate represents pressure while the horizontal ordinate measures piston stroke or piston stroke volume, can be advantageously

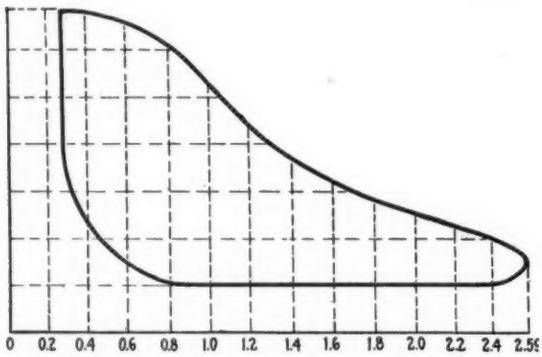


FIG. 1. INDICATOR DIAGRAM WITH VOLUME SCALE

transformed to the *T-N* or temperature entropy chart, where the vertical line represents the temperatures and the area inclosed by the admission, expansion, exhaust and compression lines measures the heat of the steam converted into work. Incidentally, the horizontal ordinate, which is the result of dividing the area by the temperature, is called the entropy of the substance. This chart was discussed in *Power*, July 18 and Aug. 1.

To effect this transformation two methods are used; the most general method will be discussed first and its errors pointed out. With this method the indicator diagram is laid out on a drafting board, and the zero clearance and the zero pressure lines are drawn. This procedure is generally known and will not be described here. After establishing these ordinates, lines parallel to the zero pressure line are drawn at any desired pressure value as shown in Fig. 1. Vertical lines are next drawn, dividing the diagram into cubic foot volume units, as shown in Fig. 1. In the engine under consideration, the cylinder is 18 in. by 36 in. stroke, with a clearance of 10 per cent. The total cylinder volume at the end of the stroke is then 2.59 cu.ft., and the diagram is divided into units of 0.2 cu.ft. The weight of steam fed to the engine per stroke must also be known; this can be obtained by weighing the condensed exhaust or measuring the steam by a flow meter. If no other line is supplied by the boiler, a fairly close value can be obtained by weighing the boiler feed. Having the weight of steam fed to the engine, which in this case is 0.25 (lb.) per stroke, and the steam-line pressure, the volume of this steam at any pressure if it were dry and saturated can be obtained from the steam tables; the cubic feet per pound of steam at various pressures are found opposite the pressure in the column marked "Sp. Vol. per Cu. Ft." It is much preferable to consider the action on the basis of one pound; consequently, the volume ordinate values of the indicator diagram should be multiplied by 4 to bring it to the basis of one pound of steam in place of one-quarter.

A table (see Table I) is prepared showing the specific volume of one pound of dry steam at the pressures indicated on Fig. I, as taken from the steam tables—as are also the temperatures, entropy of the liquid and entropy of evaporation. The curve *HK* in Fig. 2 is constructed from these values of pressure and volume; this is the *saturation line* or dry steam line for 1 lb. of steam. The diagram in Fig. 2 is the same as Fig. 1, with the volume units multiplied by 4 to represent one pound in-

TABLE I.

1 Absolute Pressure Lb. Per Sq.In.	2 State Point	3 Vol. of Dry Steam Per Pound, V	4 Temperature, Deg. F., t	5 Actual Vol. of Steam, Va	6 Dryness, Col. 5/3 X	7 Entropy of Vaporization, L/T	8 X L/T	9 Entropy of Liquid, n	10 Total Entropy, N
94	1	4.689	323.4	2.76	0.58	1.14	0.6612	0.4679	1.1291
87.0	2	5.048	317.93	3.52	0.70	1.1516	0.8061	0.4617	1.2678
73.0	3	5.958	305.79	4.24	0.71	1.1819	0.8391	0.4456	1.2847
60.3	4	7.166	292.74	5.20	0.71	1.2154	0.8633	0.4279	1.2912
45.	5	9.387	274.46	6.64	0.70	1.2638	0.8847	0.4027	1.2874
35	6	11.88	259.29	9.20	0.77	1.3054	1.0051	0.3815	1.3866
24	7	16.92	237.82	10.36	0.612	1.3665	0.8362	0.3507	1.1870
15	8	26.28	213.03	8.8	0.335	1.4409	0.4827	0.3140	0.7967
15	9	26.28	213.03	3.20	0.12	1.4409	0.1728	0.3140	0.4868
24	10	16.92	237.82	2.20	0.13	1.3665	0.1776	0.3507	0.5283
35	11	11.88	239.29	1.80	0.15	1.3054	0.1958	9.3815	0.5773
45	12	9.387	274.46	1.32	0.14	1.2638	0.1701	0.4027	0.5797
60	13	7.166	292.74	1.20	0.16	1.2134	0.1945	0.4279	0.6224
73	14	3.958	303.79	1.20	0.20	1.1819	0.2363	0.4456	0.6829
87	15	5.048	317.93	1.20	0.22	1.1516	0.2534	0.4617	0.7151
94	16	4.689	323.4	1.20	0.26	1.14	0.2964	0.4679	0.7643
100	17	4.432	327.86	1.20	0.27	1.1273	0.3058	0.4748	0.7806

stead of ¼ lb. In other words, the diagram is equal to indicator diagrams for four strokes.

The volume actually filled with the cylinder steam at the points 1, 2, 3, etc., is found by reading direct off the the volume ordinate. These values are entered in column 5 of the table. The percentage of steam in the cylinder mixture is obviously column 5 divided by

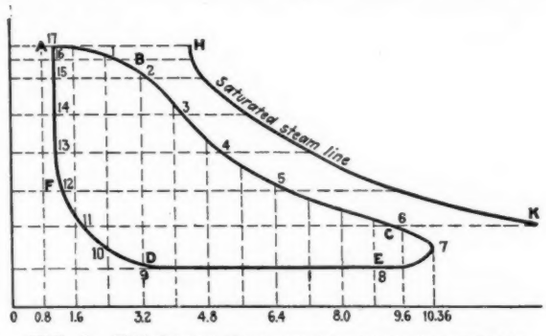


FIG. 2. DIAGRAM FOR ONE POUND OF STEAM

column 3 of the table, giving *X*. The entropy of the steam in the cylinder is the values in column 6 multiplied by the entropy of dry saturated steam in column 7, giving $X \frac{L}{T}$ which is entered in column 8. The total entropy of the substance in the cylinder is $X \frac{L}{T} + n$, the latter being the entropy of the liquid. The result, which

is N, the total entropy, is placed in the last column. An entropy chart, if not at hand, may be constructed by reading the entropies and temperatures directly from the steam tables. While the chart should have zero deg. absolute (—460 deg. F.) as the base, for convenience it is usual to cut the chart off at zero deg. F. to reduce the height. With the entropy chart constructed as shown in Fig. 3, the values of entropy and temperature in Table I are set up on the chart. The result is the temperature-entropy diagram *A B C D E F* in Fig. 4. The area of the figure gives the heat of one pound of steam actually converted into work, while the lines *A'B'C'D'A'* represent the heat which a Rankine cycle engine would convert into work when operating between the same temperature limits.

In considering the *T-N* diagram it is necessary to assume that the water is evaporated, the steam expanded and condensed within the engine cylinder. If one puts aside all thoughts of water and merely considers that it is heat which is added and taken away from the engine cylinder, it is not difficult to make this assumption. We have then heat added to the steam, which moves the piston along the line *AB*, Fig. 4. This line should be horizontal, but initial condensation and wiredrawing causes the steam to condense partly, reducing the pressure and temperature. The expansion of the steam is along *BC*. At *C* the exhaust valve opens and the heat is discharged from *C* to *E*. At *D* the exhaust valve closes, and if we assume (it being by no means true) that the same weight of steam is at all times in the cylinder, the compression line is from *D* to *F* on the *T-N* diagram. Since this line is within the saturation area, it would appear that the steam was wet; in fact, at the point of beginning of compression the clearance steam is probably dry saturated.

As a means of obtaining a diagram which gives a comparative representation of the action of the steam, this method is unobjectionable. However, it is open to serious objection if the investigator desires to obtain

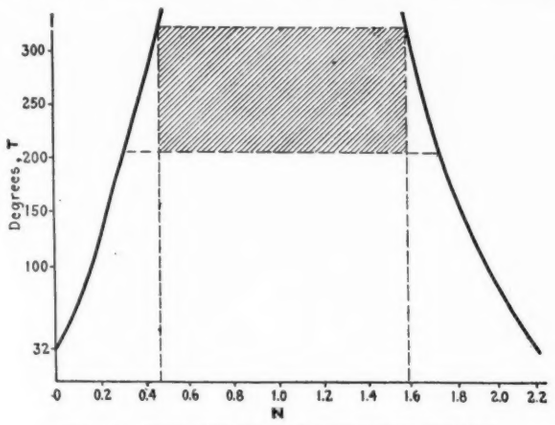


FIG. 3. TEMPERATURE-ENTROPY CHART

anything approaching a true history of the steam within the cylinder. In the first place, the indicator diagram is not the history of the action of the steam fed into the cylinder from the boiler, but covers the combined action of the cylinder feed and the compression or trapped steam. The expansion curve *BC* in Fig. 2 represents the action, not of one-quarter pound of steam, but of a greater quantity. Consequently, the position of the actual expansion line in reference to the saturation line is wrong. Furthermore, the cylinder feed should be charged with all the effect of condensation, etc., which acts upon the combined feed and trapped steam. It should be assumed that the compression steam is compressed adiabatically, which would be the case in a perfect steam cylinder. Then the work of compressing the trapped steam just equals the work done by this steam on the expansion stroke. The entire output of the cylinder is obtained from the heat in the cylinder feed steam. The trapped steam should be considered as an elastic medium expanding and compressing adiabati-

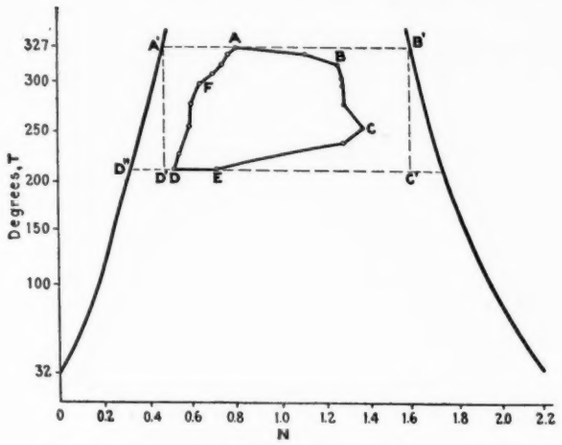


FIG. 4. INDICATOR DIAGRAM TRANSFERRED TO *P-V* CHART

cally, as if it were separated by a non-conducting diaphragm, for if this steam were not present (cylinder with no compression) the entire action of condensation and re-evaporation would occur with the cylinder feed.

In the entropy diagram, Fig. 4, it would appear that the cylinder feed was compressed from *D* to *F* and at no time condensed or completely expelled from the cylinder. In actuality, the cylinder feed is completely removed from the cylinder. In the conception used of having the steam condensed within the cylinder, etc., all the heat of evaporation is removed and the steam line must retreat to *D''* to a liquid condition and then be heated along the liquid line to *A;* this does take place within the boiler when the condensed steam or an equivalent amount of new water is heated and evaporated.

It appears that the *T-N* diagram of the cylinder feed must show the effect of the trapped or compressed steam.

To eliminate the effect of clearance, the point of exhaust valve closure is marked and an adiabatic constructed through this point. This curve touches the admission line at *E'*, as shown in Fig. 5. This curve represents the action of the trapped steam, and the volumes at the several pressures are subtracted from the indicator diagram volume at these pressures. This reduces the indicator diagram to that shown by the dotted lines. This diagram represents the action of the cylinder feed only. The saturation line *HK* is then drawn as shown, and is laid out from *DE'* instead of from the zero clearance line as before.

To construct a *T-N* diagram, the diagram is placed on cross-section paper and an entropy chart drawn as shown in Fig. 6. The *P-T* curve, showing the relation of the pressure and temperature of a pound of dry saturated steam, is also constructed, the values being taken from the steam tables. Since it is easier to deal with a pound of water rather than a fractional part, the *P-V*

diagram can be laid off on the basis of volume as if one pound is used per stroke, as has been previously done.

The volume of a pound of water is then laid off at *V-V*. This represents the zero condition of the steam when condensed, or the volume of one pound of water.

If now, a line *HW* is dropped from any point *H* on the saturated line *HK* of the *P-V* diagram until it meets a line *WB'* from the dry saturated point *B'* of the *T-N* diagram, the point *B'* being found by running a line from *H* to *H'* on the *P-T* chart, then the distance *ZW* will represent the volume of 1 lb. of saturated steam and the distance *SZ* is the volume of the same amount of condensed steam. If the point *A* on the *P-V* diagram at the same pressure and temperature as *H* is projected onto the line *ZW* in the volume-entropy chart, then the point *W'* if projected onto the line *A'B'* in the *T-N* chart will give the point *A*, the ratio of $\frac{A'A}{A'B'}$ being the per cent of dry steam in the cylinder at the point *A* in the *P-V* diagram on the assumption that the one pound of water and steam is always in the cylinder, and that at *A* on the *P-V* diagram the heat added has evaporated a part of the pound equal to the ratio $\frac{A'A}{H'A}$. Other points are projected in like manner, giving the *T-N* diagram as shown. It will be noticed that unlike the *T-N* diagram by the first method, this diagram shows the steam condensed up to the water line at *D'* as it actually does in the condenser.

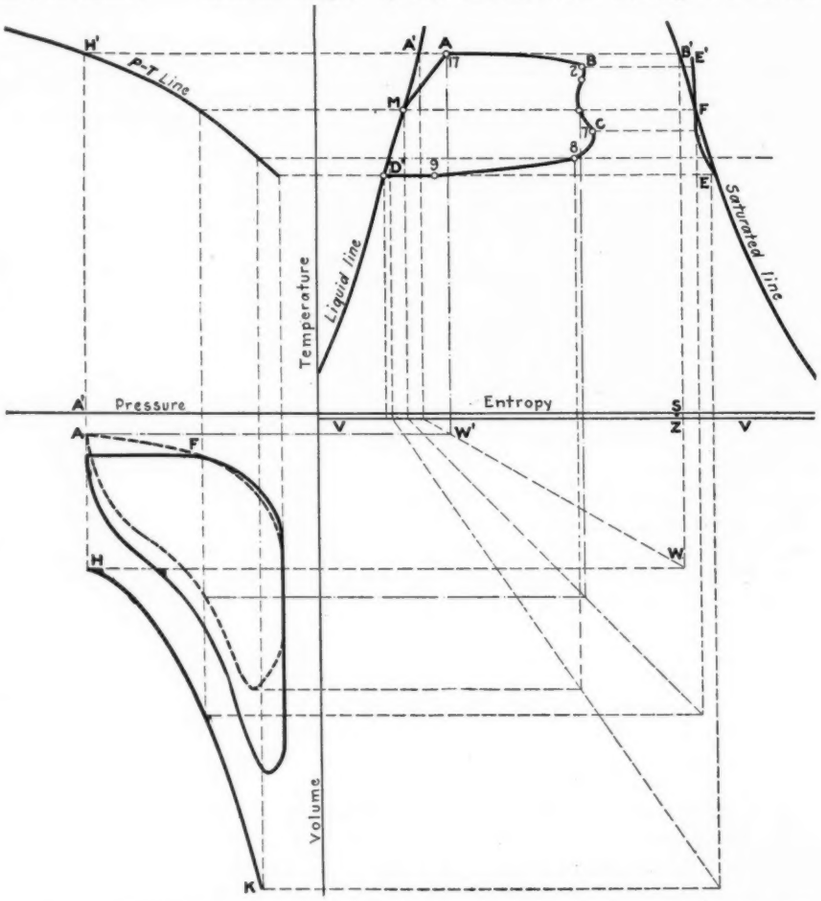


FIG. 6. CORRECT METHOD OF TRANSFORMING A *P-V* TO A *T-N* DIAGRAM

At the point *F* the steam valve opens, admitting steam into the cylinder which compresses the clearance steam. This action on the *T-N* is shown by the line *MA*, the steam entering with an increasing temperature and entropy.

The closed diagram thus formed covers the action of the cylinder feed. The exhaust or condensation line

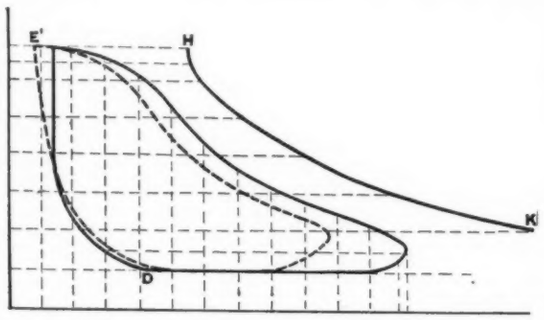


FIG. 5. DIAGRAM CORRECTED FOR CLEARANCE STEAM

7-8-9 is by no means accurate, since a constant weight of steam is not present during this portion of the cycle.

To construct the *T-N* diagram of the clearance steam the same process is gone through, giving the line *EFE'* along the saturation line. The area under the curve represents to an enlarged scale the heat actually lost during compression. As shown here the scale of the curve *EFE'* is 32.4 times the true scale, since the volume trapped by the exhaust valve closing at *D* is 0.8 cu.ft., while the vol. of 1 lb. of dry steam at atmospheric pressure is 26.27 cu.ft.

This method is more accurate, and if a set of *T-N*, *P-T*, *V-N*, charts are made up on heavy paper, they can be used for a number of investigations.

It is possible to have the suction line between the evaporator and the compressor of a refrigerating plant so well insulated and the ammonia so handled that a thermometer inserted in the suction line close to the compressor will show a temperature of 0.1 deg. when the back pressure is 30 lb. absolute. However well-insulated and water-jacketed the compressor may be, the temperature of the ammonia will increase in its passage into the cylinder. The suction valve, piston, cylinder head and cylinder walls have a temperature much higher than the incoming ammonia. The ammonia at the end of the suction stroke will not be a saturated vapor, but a superheated gas. Just what the degree of superheat will be will depend on the condition of the compressor. In a single-acting dry machine this temperature is generally 100 deg., at which each pound of superheated gas occupies 11.55 cu.ft. If the superheat should be 150 deg.—and it often is—the volume will be 12.65 cu.ft. to the pound. The output of the compressor is reduced in ratio to this increase in volume.

Burning a Low Grade of Fuel on Underfeed Stokers

UNDERFEED stokers specially designed to burn low-grade fuel, installed under 5,600-sq.ft. boilers. Plant operates at high rating and high efficiency. Front- and side-wall tuyeres used to prevent clinker formation. Steam jets installed to mix furnace gases thoroughly. Auxiliary secondary air supplied under control to dump plates which are duplex steam operated.

THE boiler plant of the Sixth Avenue Generating Station of the Twin City Rapid Transit Co., Minneapolis, Minn., contains twenty-eight 5,560-sq.ft. boilers, all originally fired with chain-grate stokers and burning a low-grade fuel.

This station supplies current to an electric railway system and operates in parallel with several hydro-electric plants which are kept constantly loaded to the limit of the available water supply, consequently this station is required to take care of the stand-by and the wide fluctuation in the railway load, which makes the requirement somewhat severe in both capacity and efficiency incident to the demands of a station operating on this class of service.

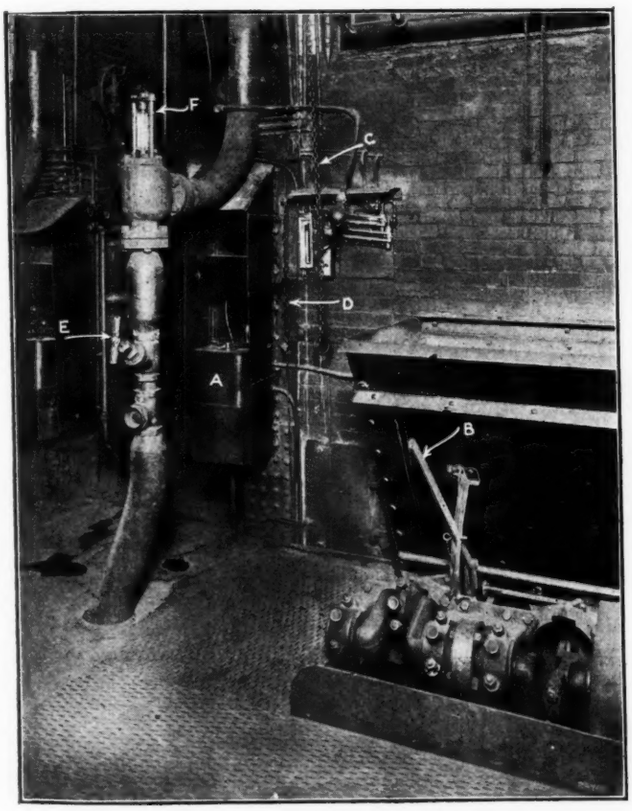


FIG. 2. CONTROL EQUIPMENT

A — Stoker speed controller. *B* — Lever regulating length of stroke of secondary ram. *C*—Uptake damper control. *D*—Forced-draft control. *E*—Feed-water valve. *F*—Feed-water flow indicator.

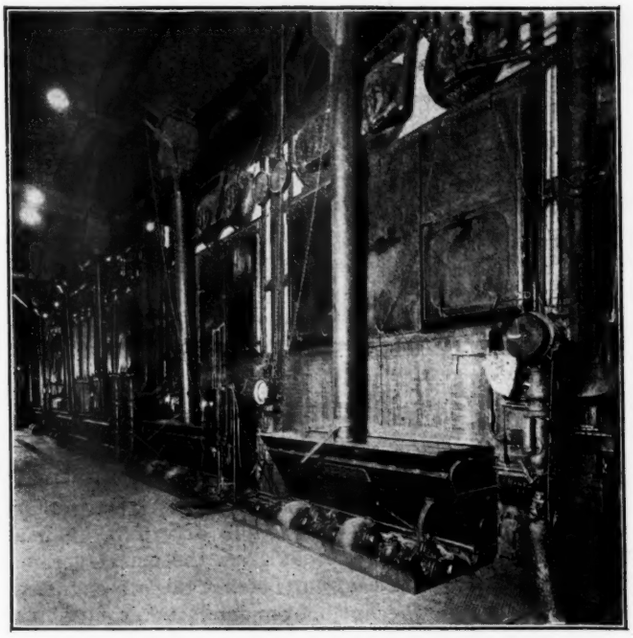


FIG. 1. BOILER ROOM FIRING AISLE

Several years ago it was decided to increase the capacity of the boiler plant and to improve its flexibility and economy. In view of the kind of coal being used, considerable doubt was expressed at the possibility of accomplishing the desired result with any type of underfeed stoker then available, for the problem of continuous and satisfactory combustion of clinkering coals of low grade, high in ash, moisture and sulphur, had not up to that time been completely solved.

The increase in capacity was, however, successfully accomplished by redesigning the setting of six boilers and replacing the chain-grate stokers with specially designed ones of the underfeed type and has made possible the operating of the boiler up to 350 per cent of rating, thereby materially increasing the capacity of the boiler plant.

The boilers on which the alterations were made are B. & W. water-tube, 13 tubes high, 21 tubes wide and of 5,560 sq.ft. heating surface with 900 sq.ft. superheating surface and no economizers. The stokers installed are Westinghouse six-retort underfeed, 10 ft. 8¼ in. in width, 10 ft. ⅞ in. in length, set flush with the boiler front. As the bottoms of the front tube headers are only 8 ft. above the floor line, it was necessary to set the stokers 3 ft. below the floor level to secure the desired furnace volume of approximately 1,300 sq.ft.

The steam conditions at which the boilers operate are 190 lb. gage and 100 deg. F. superheat at nominal rating.

Stokers of Special Design

For the proper combustion of the low-grade fuel used, several new features were developed and incorporated in the design of the new stokers. The fuel as it is introduced from the retorts by the rams is spread laterally by deflector plates so as to cover the surface of the tuyeres. The action of these plates also loosens the fuel, which, when containing large percentages of moisture and dirt, becomes densely packed under the action

of the rams. Secondary step-shaped rams, located midway between the deflector plates and the grate tuyeres, insure a continuous movement of the fuel bed. These rams under independent control extend in their action practically to the dump grate, filling in blowholes which may start and also building up the fuel bed to a uniform thickness. Thus the auxiliary rams furnish means for controlling the distribution of coal over the fuel bed and for agitating slightly the lower fuel bed. At the same time all grate surface is made effective for combustion. Thus it is seen that a fuel bed of uniform thickness is made to travel steadily toward the rear. In practice the stoker has been found to maintain these conditions.

Adjustment of Secondary Rams

The length of the stroke of the secondary rams is regulated by one adjustment lever. On the upper end of the auxiliary-ram driving rod is a block with four notches, which is engaged by a pin driven through a fixed stroke by a series of links from the primary ram. According to which of the four notches the pin engages, the lost motion of the link movement is taken up so as to vary the stroke of the secondary ram from zero to 6 in. The control of the lost motion is effected by the use of a selector block which slides under the pin and prevents it from engaging any but the desired notch. The details of this construction are shown in the cross-sectional view of the stoker.

To protect the front and side walls adjacent to the fuel bed and prevent the formation of clinkers at this point, extension tuyeres were used. These extend approximately to the top of the fuel bed. Both the side-wall tuyeres and front-wall air boxes admit a limited amount of air underneath and near the surface of the fuel bed, tempering the gases and forming a cool blanket over the lower furnace walls. The reduced temperature in that region is helpful in protecting the brickwork. A battery of high-velocity steam jets placed in the front wall about 18 in. above the fuel-bed surface and directed parallel to that surface, insures complete combustion by thoroughly mixing the gases before they enter the tubes. These jets also divert the gas flow toward the back wall of the furnace, providing for a sweep of the gases over the full length of the exposed boiler tubes.

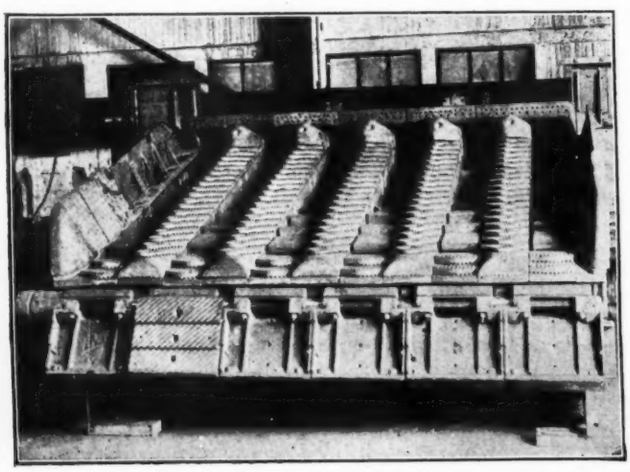


FIG. 3. VIEW OF STOKER IN COURSE OF ERECTION

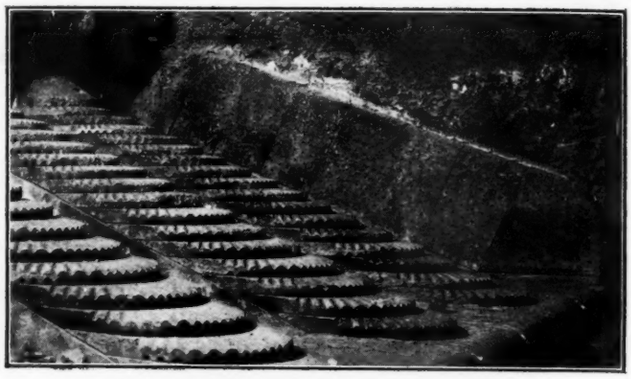


FIG. 4. SHOWS SIDE WALL TUYERES

For the discharging of clinker and ash at the rear end of the grate, duplex dump plates are provided, one of which is hinged to the lower end of the stoker and the other to the rear wall support. Each is actuated by an individual steam ram located on the outside of the boiler setting. The stroke of these rams can be controlled by the setting of a collar on the piston. The front dump grate, by its lifting action, may be used to break up clinkers as they pass to the rear dump and also to hold back the fuel bed when the rear dump is dropped. Air for combustion is supplied under control to both front and rear dump grates. This auxiliary air supply enters through a duct enclosed in one of the steel members that support the lower end of the bridge wall. The entire grate surface thus becomes active when required, and the carbon is burned down to a low percentage of the refuse before dumping. Also ashes may be dumped frequently on heavy loads without interfering with the output or efficiency, and refuse is disposed of before it builds up into large clinkers.

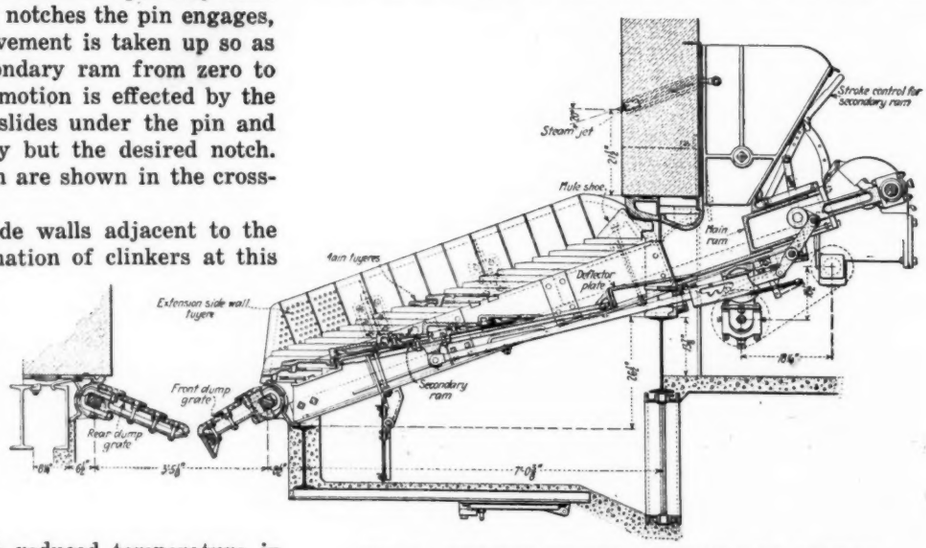


FIG. 5. SECTION SHOWING DETAILS OF STOKER

Changes Made in Baffling

With the increase in boiler capacity that would be obtained by the installation of the underfeed stokers, considerable change was made in the boiler baffling. It was designed to give practically a constant gas velocity by increasing the cross-section of the passes in the same

ratio that the gases contract due to the abstraction of the heat by the tubes. The bridge wall and baffling are so located as to expose 90 per cent of the tube length, giving a tube area double that of the grate to absorb heat by the direct radiation from the fire. The bridge wall rises from the dump grate to a level with the surface of the rear of the fuel bed and then recedes to the rear, meeting the tubes at the back end of the boiler. With this condition of tube exposure it is estimated that over 50 per cent of the total heat is absorbed in the first two rows of tubes. The high heat absorption front and bridge wall are so arranged that the radiant heat which does not enter the tube surface directly reaches the boiler with but one reflection. Such a condition means that the maintenance of furnace walls and other brickwork is considerably lowered by the elimination of double and triple reflections. After 18 months' operation the furnace settings have required no repairs of brick linings and there is practically no accumulation of slag on the walls.

The area of the superheater surface was increased approximately 63 per cent, as it was estimated that the

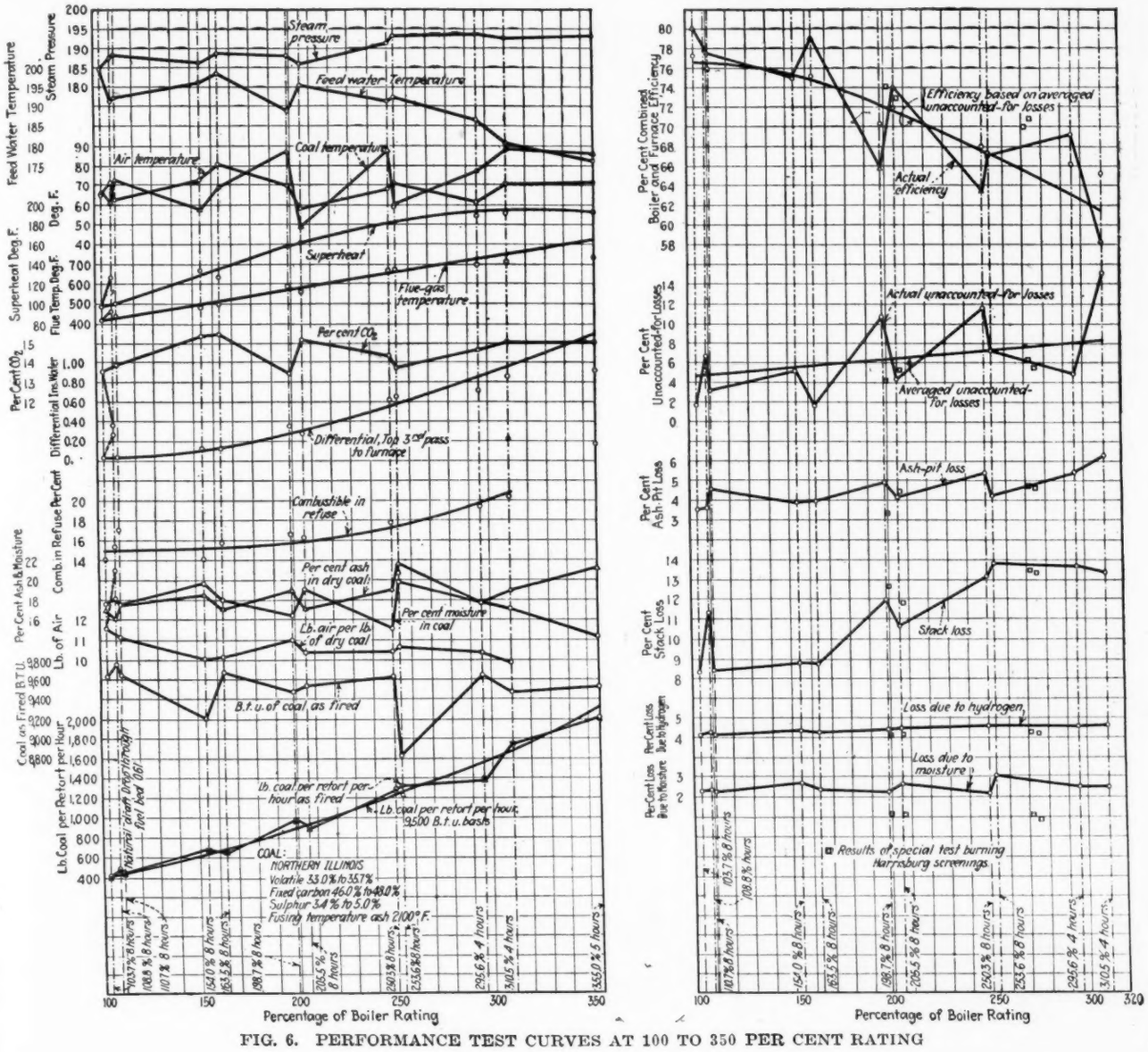


FIG. 6. PERFORMANCE TEST CURVES AT 100 TO 350 PER CENT RATING

directly by radiation accounts largely for the low furnace temperature and consequently a minimum of clinker formation. Before dropping on the bucket conveyor, the ashes must pass through an 8 x 8-in. cast-iron grid. If there were excessive clinkering, this system would be objectionable because the refuse would have to be reduced to the proper size before it could be handled in the conveyor.

With the installation of the new stoker and the redesigning of the furnace, the angles of the stoker, the temperature of the gases as they entered the second pass would be considerably lower than formerly, owing to the heat absorbed directly from the fuel bed by the first two rows of tubes, owing to the change in the baffling. The superheater, consequently, was lengthened so that the bends extended over the first pass instead merely of just up to the first baffle. This gives the effect of a double-pass superheater. Its area was increased from 550 to 900 sq.ft. by this extension to be sure that at least the same superheat would result. When

operating at about 170 per cent of rating, the superheat formerly averaged about 100 deg. F., and the chart, Fig. 6, shows how it was increased to 140 deg. F. at this rating and also how it continued to increase as the boiler was forced to higher ratings.

The construction of the rear baffle was worked out, which made it unnecessary to utilize the superheater headers to support the baffle tile. Instead of baffle tile in that position, between the lower superheater headers and the boiler drums, ½-in. Transite board has been used. It is secured between two "L" holders, the upper one being hung from ⅞-in. rods passing over the boiler drums. The lower one is built into the section of tile baffling resting on the upper rows of boiler tubes. Seven sections, 21 in. by 4 ft., are required per boiler, each section being reinforced vertically with an angle and a channel. The advantage of this type of construction is that the baffling is readily removable and that it is independent of the expansion and contraction of the superheater risers.

By referring to the boiler record chart Fig. 8 it will be seen that the equipment has demonstrated the possibility of operating at any capacity up to 350 per cent of rating. At this high rating low-grade fuel is burned at a rate of one ton per retort per hour, and the refuse is disposed of with no excessive loss of carbon or loss

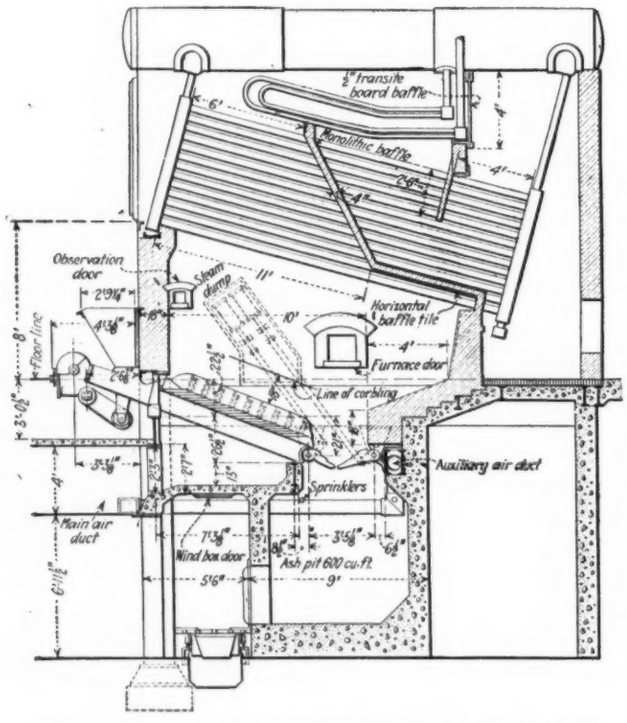


FIG. 7. SECTION OF BOILER SETTING AND STOKER INSTALLATION

of capacity or efficiency while dumping. Whether this high rating is the limit of the stoker capacity has not yet been determined, for the rate of evaporation was limited by the capacity of the feed pump and the feed line to supply the boiler with water.

This design of stoker and furnace has demonstrated other advantages. It is possible to control the air supply to the most efficient proportions, little if any slag is formed on the furnace wall, and the highest efficiency is secured at or near normal rating. The stoker maintenance has been low and the percentage of combustible in the ash has been reduced to a negligible proportion.

In Fig. 6 are shown the curves that were obtained from a series of twelve tests, at outputs ranging from 100 to 350 per cent of rating, conducted under the direction of E. H. Scofield, engineer of power, and by representatives of the Westinghouse Electric & Manufacturing Co. and of the Twin City Rapid Transit Co. The

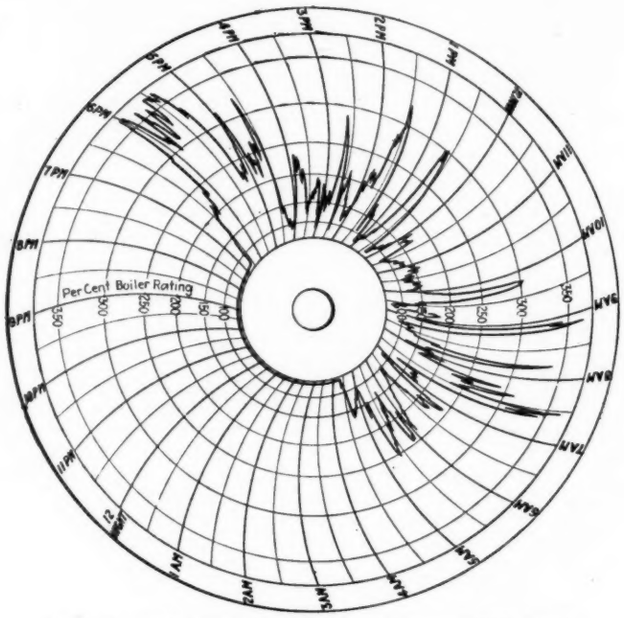


FIG. 8. PER CENT BOILER RATING DEVELOPED

fuel characteristics and operating conditions varied as outlined in the following tabulation, the result of each test being reduced to a basis of conditions shown in the third column:

	Minimum	Maximum	Curve Basis
Coal:			
Moisture, per cent	14	20	18
Ash, per cent	16	22	18
Sulphur, per cent	3.5	5	4
Volatile, per cent	32	35	33
Fixed carbon, per cent	45	48	45
Ash fused at, deg. F.	.....	.....	2,100
B.t.u. commercial	8,827	9,750	9,550
B.t.u. dry	.....	.....	11,650
B.t.u. combustible	.....	.....	14,200
CO_2 at top of third pass, per cent	13.5	15.5	14–15
Carbon in refuse, per cent	13.0	20.0	15–20
Uptake temperature, deg. F.	415	740	400–750

While the efficiencies on test range from 77 per cent at normal rating down to 60 per cent at 350 per cent of rating, the average operating economy is placed at about 70 per cent. Considering the wide and sudden variations in load and the character of the fuel, this performance is excellent. It may be compared to an average of 60 per cent for the older installation.

That considerably better results can be expected with a higher grade of fuel was indicated by four tests made at loads ranging from 200 to 275 per cent of rating with Harrisburg screenings of the accompanying analysis. The results are indicated by the squares in Fig. 6.

ANALYSIS OF HARRISBURG SCREENINGS

	Per Cent
Combustible	77.87
Moisture	9.90
Ash	12.23
Volatile—dry coal	29.48
Fixed carbon	54.11
Sulphur	2.81
Ash	13.60
B.t.u., commercial	11,304
B.t.u., dry coal	12,541
B.t.u., combustible	14,514

During the twelve tests no large clinkers were formed at any time, no slice-bar work was required on either side wall or bridge wall, and no slag formed on the furnace walls or boiler tubes. The dumping periods were frequent and there was no appreciable drop in the percentage of CO_2 or in the steam flow. Such furnace conditions provide a unit of great flexibility peculiarly adapted to stand-by and to intermittent demands and to meet the most exacting requirements of railway and power loads. They also reduce the banking losses to a low figure, the amount consumed during banked period being around 250 lb. per boiler per hour.

What Determines the Size of the Oil Drop

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

AFTER the best mechanical atomizing appliances have been provided, and when the oil is fed at the best place for thorough atomization and distribution, it becomes necessary to consider the effect of the properties of the steam and the oil.

Three properties of the steam itself might be expected to have some influence on atomization—pressure, temperature and moisture. Pressure apparently has no influence whatever upon the size of the drops. The compressibility of oil is too slight for the existing pressure to have any bearing on the size. We may assume that, if pressure were the only influence, the size of the drops would be exactly the same in steam at 200 lb. pressure and at 25 in. vacuum. Pressure may have some effect upon the distribution of the oil through the whole volume of the steam, in that when equal quantities of oil are fed the quantity of oil per unit weight of steam will be lessened as the steam pressure is increased. This might possibly necessitate the use of more oil per unit volume of high-pressure steam.

Temperature Affects Size of Drop

Temperature, however, has a very decided influence upon the size of the drop, and, since high temperatures accompany high pressures, the oil drops carried by high-pressure steam cannot be as large as they might be in low-pressure steam. The steam temperature affects the size of the oil drop only because it raises its temperature. Two properties of the oil are affected by heat, its surface tension and viscosity.

The surface tension of a liquid might be defined as the property which causes the surface to contract into the smallest possible area for a given mass. It is this property that causes drops suspended in a gas or vapor to be round instead of some other shape. A liquid that has a high surface tension will hold a larger weight in a single drop than another liquid with a lower surface tension. This means that an oil having a low surface tension will divide into smaller drops than one having a higher surface tension. Heat reduces the surface tension, which means that a high temperature is of greater assistance in the formation of small globules than is a low temperature.

Temperature further improves atomization because it reduces the viscosity of the oil. A viscous oil is not so readily atomized as a thin oil; it adheres to the feed pipe and is not so readily blown off. All oils thin out as they are heated, and on this account a high temperature facilitates the mechanical division of the oil into small particles. We learn from experience that a low-viscosity cylinder oil will atomize more quickly and more completely than a high-viscosity cylinder oil.

We would expect that an oil would atomize much more readily in the steam line to the high-pressure cylinder than in the line to the low-pressure cylinder of a compound steam engine, and such is the fact borne out by practical experience. This is the reason why it is sometimes considered advantageous to use a lighter-viscosity oil for the low-pressure cylinder than for the high-pressure cylinder.

Change to Lighter-Bodied Oil Sometimes Beneficial

When operating conditions are fixed beyond any adjustment, and when there can be no change made in the location of the feed line, the lubrication of a cylinder sometimes can be greatly improved simply by using a lighter-bodied oil, because the heat available in the steam will atomize the lower-viscosity oil more quickly than the high-viscosity oil. Generally, the low-viscosity oil has a lower surface tension, and in many instances the improvement may be due largely to the lower surface tension, when we give the credit to the lower viscosity.

Moisture in the steam also improves the atomization, because the surface tension of the oil when in contact with water is less than when in contact with dry steam. Consequently, some of the drops that are formed, particularly those in immediate contact with the moisture, will be smaller than if there were no moisture present at all. This effect is entirely different from that of the formation of a globule completely enclosed in water, as the relative densities of oil and water are so close together that a large drop can be formed.

Aside from the viscosity (and here we mean the viscosity at the steam temperature, not at some other temperature) and the surface tension, there are two other properties that have some influence upon atomization. One of these is compounding and the other is filtration, or degree of refinement.

As we have seen in the previous articles, compounding consists of the addition of an animal oil to the mineral cylinder oil. These animal oils have

MR. OSBORNE has, in previous articles on lubrication, cleared up a good many problems for the engineer. Here he explains the reasons why the oil drops going to the engine cyclinder may vary in size.

a lower surface tension than the mineral oil, particularly in the presence of moisture, and when they are in solution have a tendency to reduce the surface tension of the mixture. They also reduce the viscosity slightly. It would seem that a compounded oil would atomize a little more quickly than a straight mineral oil, and such is probably the case.

Filtration Improves the Atomization of Steam Cylinder Oil

Filtration improves the atomization of a steam-cylinder oil in a similar manner. A filtered cylinder oil will atomize much more quickly than a non-filtered oil of the same viscosity, because the filtration process has removed certain compounds which increase the cohesion and the surface tension of the oil. Filtered cylinder oils have been found quite beneficial in certain cases where steam separators were located so close to the throttle that insufficient time was permitted for the proper atomization of the oil before it reached the cylinder. An oil line located between the boiler and the separator would be of no value because the separator would remove all the oil, so that point of introduction nust necessarily be located directly at the throttle in such cases.

Filtered cylinder oils should be used with care however, as they have certain disadvantages in their ability to remain on the cylinder wall in the presence of moisture.

Q. How can I tell when atomization of the cylinder oil is right?

A. When the engine is running, good atomization of the oil can be recognized by the character of the condensed steam leaking past the stuffing box, and in the exhaust. The condensed steam should be milky in color, bearing in suspension minute globules of oil. If there is any liquid oil on the surface of the water, one of two things is happening. The oil is not atomizing properly, owing to unsuitable oil or improper mechanical conditions, or the oil is being fed in such large quantities that the steam cannot hold it all and a part of the oil remains unatomized.

A properly atomized oil will also show up by forming a good film on the piston rod. When a suitable oil is used and it is being properly atomized, it is seldom necessary to lubricate a piston rod from the outside. A sufficient amount of oil should be deposited on the rod from the steam within the cylinder. This does not hold true in case the rod is badly scored, requiring snug packing.

Q. Is it necessary to feed oil to the low-pressure cylinder of a compound engine, if a suitable oil is supplied to the high-pressure cylinder?

A. A correct oil, properly atomized before it reaches the high-pressure cylinder of a steam engine, will remain in suspension in the steam until it comes in contact with a cooler metallic wall or is entrained mechanically by water and forced to separate out. The former action, condensation on a cool surface, gives us cylinder lubrication. If there were no separation of water in the receiver, the oil would be carried through to the low-pressure cylinder and it would be satisfactorily lubricated.

However, condensation of water does take place in the receiver and a considerable portion of the oil is removed here, as can be seen by an examination of the discharge from the receiver traps. The compounding in the oil, in particular, is more than likely to be removed from the steam at this point.

On this account, although some oil will be carried over to the low-pressure cylinder, it is usually necessary to introduce more oil into the valve chest of the low-pressure cylinder in order to get satisfactory lubrication. If the receiver has reheating coils, there will be little condensation and no settling of the oil coming from the high-pressure cylinder.

The Difference Between Priming and Foaming

Priming and foaming are so closely related that the words themselves are often confused, although they do not mean the same thing. Priming means the carrying of water over into the steam pipes. The term does not, however, include the one or two per cent of permissible moisture that is found in the form of fine mist or fog in the steam.

Now, foaming, which is one of the causes of priming, means the piling up of bubbles on top of one another, owing to a certain "stickiness" in the water. This stickiness, or increase in surface tension, may be due either to finely divided solid matter or to dissolved salts.

The action may be observed on any cookstove. When clean water is boiled in a sauce pan, the bubbles of steam break as soon as they reach the surface of the water. Unless the rate of boiling is extreme, there is no tendency for the bubbles to pile up. Now if some salt, sugar or other foreign substance (either soluble or finely divided, if insoluble) is added, foaming will occur, with the likelihood that some of the foam will spill over the edge of the pan.

This piling up of the bubbles due to the stickiness or soapiness of the water, this filling of the boiler and distributing system with a mass of suds, is properly called foaming. Foaming can cause a certain amount of priming, but the small slugs of water carried over by the light foam are much less serious than those that may result from what may be called "spouting." When a boiler is operating at high ratings, the water tends to heap into mounds or spouts at certain points. This action may be caused by restricted surface (as too many tubes in horizontal return-tubular boilers), limited steam space, giving the outlet too direct a draft upon the agitated water surface, etc. Evidently, this "spouting" is mainly a question of boiler design.

While the mass of water raised by spouting contains a large percentage of steam bubbles, it is much nearer to being solid water than are the light suds formed by foaming. So when spouting gets to such a stage that the mass of water reaches the dry pipe, serious priming is likely to occur.

When either the forced feed or splash system of lubrication is used on an oil engine, it is important that there be some arrangement whereby the splashing of oil onto the hot piston top is avoided. This may take the form of a baffle in the piston itself, a separate hollow piston head or a light guard placed over the crank throws. Each of these arrangements is used with success. With the types of lubricating systems mentioned, an oil ring at the lower end of the piston is of assistance in preventing the oil from creeping up along the piston into the cylinder.

EDITORIALS

Mystery Stuff in Industry

THE small boy loves a secret; the hidden cave and the mystic password give him endless thrills. When he grows to be a man, he can still indulge himself in similar delights by membership in various fraternal orders. Such membership may be of real benefit to him and do no harm to others.

But the same instinct, combined with a short-sighted view of business relations, has led many a business man to throw the cloak of mystery over his "trade secrets." He does this to keep them from his competitors. Yet in nine cases out of ten they already have the information.

"Experience in dealing with producers of different commodities has shown that secrecy is largely a method by which producers have been fooling themselves," says George Otis Smith, the director of the United States Geological Survey, who has had long contact with production statistics. "Those who really wish to know the scope of competitors' activities have plenty of ways to find out. Secretive operators, who eventually decided to change their methods, have been surprised very much on disclosing their secrets to find that these secrets already were well known to their competitors."

The industries that make the greatest progress are those where co-operation replaces suspicion and where energy is directed into productive channels rather than wasted in the attempt to preserve trade secrets. Manufacturers that co-operate in obtaining and disseminating knowledge of common value find their reward in many ways. Unfair competition grows less as competitors come to know and trust one another. Production costs are reduced to the mutual benefit of producers and consumers. Finally, the good will of the consumer—a matter of first-rate importance—is best fostered by an attitude of frankness in regard to methods of manufacture and distribution. On the other hand, secrecy invariably breeds suspicion.

Central Stations Show Improved Economy

THE United States Geological Survey regularly compiles statistics covering the fuel consumption and electrical output of public-utility power plants. These totals for 1921, just received, afford interesting comparisons with 1920. Owing to the industrial depression which started early last year, there was a falling off in load of nearly six per cent. That this would have been accompanied by reduced efficiency might readily be assumed; but the contrary appears to have been the case, in the steam stations at least. Based on coal equivalent, the average for the steam stations was 2.73 pounds of coal per kilowatt-hour in 1921 as against 3.03 pounds in 1920—an improvement of ten per cent.

In seeking an explanation for this, one must consider several contributing factors. It will be remembered that industry was running strong for the greater part of 1920, and in order to meet the power demands many utility plants had in service older and less efficient equipment, pending the installation of new units. Moreover, the operators often did not have the opportunity to take equipment out of service for needed overhauling. By 1921 a number of large new stations were in operation, and it was thus possible to secure more advantageous loading of the systems. Also the coal situation was more satisfactory in the latter year. Still another significant factor was the extra effort on the part of managements to offset decreased demand by closer attention to operating efficiency.

But demand has again increased and, according to statistics from the same source, that for the first six months of 1922 has eclipsed the demand for a like period of the banner year, 1920. However, the utilities are now better prepared to handle the loads because of the new plants and additions to older ones, as is shown by a further reduction in fuel consumption to 2.59 pounds per kilowatt-hour. Whether this can be maintained or improved upon during the remainder of the year may depend to some extent upon the coal situation.

Gennevilliers and American Power-Plant Practice

IN THIS issue the heat balance and electrical equipment of the Gennevilliers station are described. It is interesting to note that this station, which is supposed to represent the best practice in European design, follows along in many respects the tendencies in power-plant construction in this country. This is particularly true in the electrical design. However, certain features cannot be considered standard practice. One of these is the connection of the generators directly to the step-up transformers without even a disconnecting switch between the two equipments. This arrangement has been used in some cases in this country in hydro-electric stations, but not in steam plants.

Where all the power is transmitted at a high potential, as from Gennevilliers, the low-tension buses and oil switches can be eliminated to good advantage, with a considerable reduction in cost for equipment and construction, as well as a material saving in space and simplification of the electrical layout. Of course the scheme lacks flexibility, in that it is not possible to switch any generator to any bank of transformers. This is not a serious objection, since the weak link in the chain is in the turbine and generator. Experience has shown that the large percentage of outage is in the turbine and generator and not in the transformers. Furthermore, in case of a transformer failure, the faulty unit can readily be replaced by a spare, and proper provisions can be made for doing this at comparatively low cost.

In this country most of the large steam-electric plants are located within a comparatively short distance of a considerable percentage of their loads, and this is served at generator voltage, making low-tension switching and bus equipment necessary. On the other hand, the Ameri-

can operating companies have not taken very kindly to the installation of high-tension underground cables. In this respect Gennevilliers represents a distinct step forward, using underground conductors for sixty thousand volts.

It is evident that the designers of the Paris station were well aware of what the American power-plant operator has learned by many costly experiences; namely, that high-speed turbo-generators must be protected so that they can be made dead automatically in case of internal trouble and that the windings must be kept clean in order to eliminate the fire hazard as far as possible. Both the generators and transformers have been provided with differential relay protection, which is becoming general practice in this country, particularly for generators, although it has been applied in some cases to power transformers.

The re-circulation of the generator ventilating air is a practice that is beginning to receive favorable consideration by operators in America, and there are at least three plants where such installations are in operation. In all of these the air is cooled by re-circulating through water sprays, whereas at Gennevilliers an indirect system of air cooling is used by passing the air through water-cooled radiators, through which the condensate and the boiler makeup water are circulated. To further reduce the fire risk in the generators, it is proposed to circulate pure nitrogen through the machines instead of air. If this can be carried out successfully, the fire hazard will be practically eliminated. Although the use of an inert gas as a cool medium has not been adopted in this country, in one installation where a closed system of ventilation is used, provisions have been made for admitting carbon dioxide into the machine, should a fire start in the windings.

Although the steam equipment in Gennevilliers, as described in the issue of August 1, does contain a number of features that are departures from what has been adopted in power-plant design in this country, on the electrical end, outside of the high-voltage underground cables, there is little that can be called different from what has already been tried in America. However, the station as a whole represents a move off the beaten path in power-plant design, and if present tendencies are correct, then Gennevilliers is a step in the right direction.

The Modern Oil Engine

IN DISCUSSING the heavy-oil engine, engineers are too much inclined to revert back to its early history in judging its present comparative worth. It is true that at one time breakages of crankshaft, cylinders and cylinder heads were frequent, but this is by no means different from the results obtained with other prime movers when first built.

Realizing that engineers should appreciate the wonderful strides made by the oil engine in recent years, Dr. Lucke describes in this issue some of the difficulties met with and the steps taken to overcome them. As he points out, the greater number of parts of an oil engine closely correspond to like parts of the steam engine, and these in themselves have given little trouble. It is the process of combustion within the cylinder that caused most of the high maintenance of former days. The method of introducing the fuel into the cylinder is better understood now, and as a consequence broken parts are seldom encountered.

Dr. Lucke states that there is but little difference in the results obtained from two- and four-stroke-cycle engines. One has more moving parts, but to offset this disadvantage has a better fuel consumption. Many may disagree with his contention that the small units should be two-stroke-cycle while the large engines should be four-stroke-cycle, for apparently both types are used successfully in the same capacity range.

Of especial interest is the discussion on the solid-injection engine. If it is possible to build an engine without an air-compressor that will show as good results as the air-injection Diesel, it would seem that by a lower manufacturing cost the former would speedily overcome the Diesel's superior position.

Apparently, the solid-injection principle will be used only on engines of small powers when the advantages of the air-injection Diesel cannot offset the decrease in interest charges resulting from the use of the cheaper unit. Undoubtedly, in time each type will find its own field, when it can be used to the greatest advantage, in the same way that the semi-Diesel at the present time has a range of capacities where it proves more economical than the Diesel.

Extending the Use of Underfeed Stokers

THE impression that underfeed stokers are successfully adapted only to coals with heavy coking properties and limited percentage of ash is slowly dying out, and recent developments and installations would tend to place this theory in discard. In this issue are described the alterations made in a boiler plant, which materially increased its capacity with the same grade of fuel.

The changes made in the boiler setting are in line with present practice, and full advantage has been taken of the opportunity of increasing the boiler efficiency and reducing the furnace temperature by exposing as much as possible of the lower tubes to the full glow of the furnace.

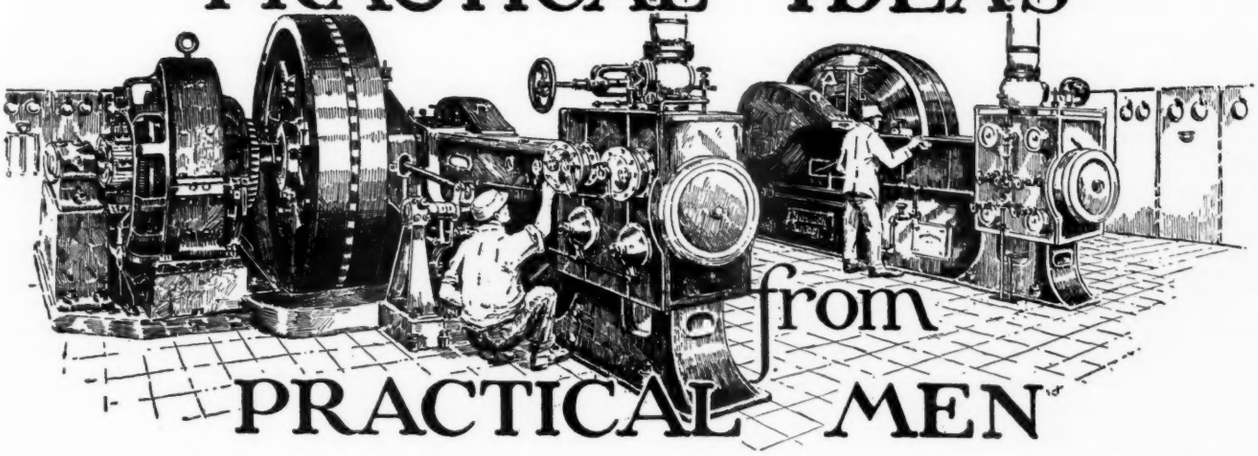
Other features of the installation are the use of extension tuyeres to protect the furnace wall and prevent the adherence of clinker, also the use of steam jets a short distance above the fuel bed to insure complete mixing of the furnace gases.

Although the heat loss due to the presence of combustible in the ash is usually overestimated, provision has been made here for reducing this to a minimum by sealing the ashpit and supplying secondary air below the dump plates. This has resulted in the percentage of combustible falling well below the average.

Not only are underfeed stokers adaptable to low-grade bituminous coal, but there are installations that are burning lignite coal successfully, the one disadvantage being the decrease in boiler rating obtainable and the necessary increase in the number of boilers operated. However, this is overbalanced in most cases by the cost of operation remaining practically the same as with bituminous coals. The fact that these stokers have a wide range in the burning of different fuels has been a decided advantage during the present coal strike.

With industry beginning to feel the pinch of the coal strike and the Government assigning priority to the railroads, one wonders at the continued advertising of Sunday excursions.

PRACTICAL IDEAS from PRACTICAL MEN



Water Still for Storage Batteries

A large and increasing number of storage batteries are in use in generating and substations, and considerable distilled water is required in some stations to replace that lost by evaporation. While it is usually possible to purchase the necessary water, it is sometimes more desirable to distill it, and directions for constructing a still suitable for the purpose follow.

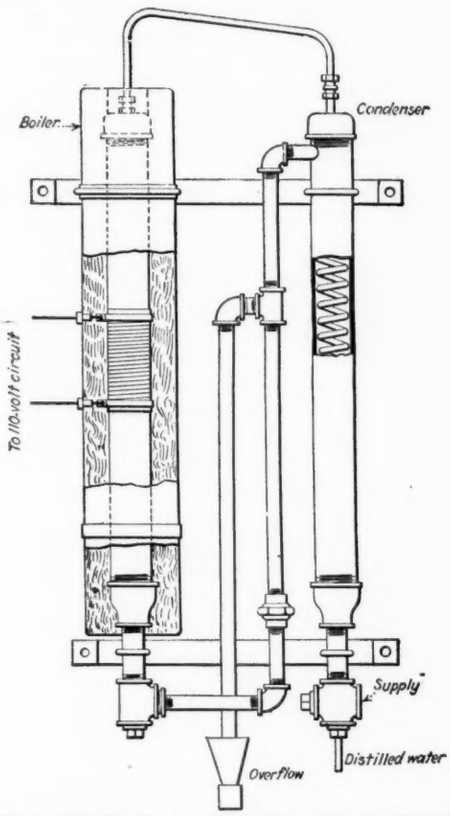
Referring to the sketch, it will be seen that the still consists of two major parts, an electrically heated boiler and a condenser. The boiler and condenser are connected by piping and mounted on two flat iron supports.

The boiler should be constructed of 2-in. brass pipe, but copper or galvanized iron pipe may be used. The lower end of the boiler terminates in a 2x1-in. brass reducer, and a brass cap covers the upper end. This cap should be drilled and tapped to receive a ⅛-in. copper tubing connector. There should be a space of about 18 in. between the cap and normal water level in the boiler, to form a steam dome. Slightly below the water level or overflow connection the heating coil is placed. The distance from the bottom of the heating coil to the reducer should not be less than 16 in., in order to prevent the possibility of the hot water flowing back through the overflow pipe. The boiler should be well covered with magnesia pipe covering about 2 in. in thickness.

In the still shown, 32 ft. of discarded No. 20 Nichrome resistance wire was wound on two layers of 0.015-in. flexible mica placed on the brass pipe. Asbestos may be used, but mica is much superior, and may be best applied by first warming the tube and binding the mica to it with a few turns of strong thread. The resistance wire should be wound on the mica under considerable tension, spacing the turns about 0.1 in. apart. Winding can be best done in a lathe, and asbestos string may be wound between the turns to prevent the possibility of short-circuits developing. The completed winding should be held in position by brass or copper clamps, and these will also serve for terminals. The clamps should be placed at least ½ in. from the edges of the mica. No. 10 asbestos-covered wire, which passes through porcelain tubes inserted in the magnesia pipe covering, should extend a few inches from the boiler and then be connected to rubber-covered wire. Current for the heating coil should be supplied through a 15-ampere fused switch.

If an iron boiler is used, less wire, as compared with a non-inductive boiler of copper or brass, will be required, and any resistance wire will prove satisfactory, provided enough is used to limit the energy consumed to 800 watts, without operating the wire at a destructive temperature.

The condenser is made of 2-in. galvanized iron pipe, of the same length as the boiler, and contains a coil



ARRANGEMENTS OF BOILER AND CONDENSER

consisting of 10 ft. of ⅛-in. copper tubing wound over a suitable mandrel. All the copper tubing used should be tinned on the inside. A galvanized iron pipe cap is screwed on the upper end of the 2-in. pipe and drilled for a close fit for the tubing, which passes through the cap, into which the tubing is sweated. In order to prevent surging of the water flowing into the boiler a

⅛-in. hole should be drilled through the top of the cap, to admit air. It would be better to use a small pet cock at this point, so that the condenser may be made tight while testing or cleaning.

The lower end of the 2-in. condenser pipe terminates in a 2x1-in. reducer, and a 1-in. galvanized iron nipple connects the reducer with a 1-in. cross. The copper tubing passes through the nipple, and through a 1-in. solid brass plug in the bottom outlet, the tubing being sweated into this plug. One side outlet of the cross connects, through a suitable valve, to the water mains. The other outlet is closed by a brass plug, to be removed when it is desirable to clean the condenser.

The upper end of the condenser is connected, by means of ½-in. galvanized iron pipe and suitable fittings, to a 1-in. tee at the bottom of the boiler. The lower outlet of this tee is closed by a brass plug. As shown, the overflow pipe connects to a tee above the union and empties into a funnel-shaped drain.

When the still is in operation, the fresh water enters at the bottom of the condenser, flows upward, condensing any steam in the coil, thence from the top of the condenser to the bottom of the boiler. The temperature of the incoming water is considerably increased by the steam in the coil, and any excess water flows out the overflow pipe. The steam is conveyed through ⅝-in. copper tubing from the top of the boiler to the condenser, and a connector and union should be used to facilitate making this connection.

With an energy consumption of 800 watts the still described should produce 1.3 pints of distilled water per hour, and should begin to operate about 45 minutes after the heater is energized. The only precaution to be observed while the still is in operation is to see that a small amount of water flows from the overflow pipe. In order to avoid corrosive fumes, the still should not be placed in a battery room, and the distilled water should be kept in closed earthenware receptacles until used. The distilled water outlet should be about three feet above the floor.

From the foregoing description it is evident that by using standard parts and materials a satisfactory still can be constructed at reasonable cost. Furthermore, modifications and improvements may suggest themselves, such as arranging the piping so that the still may be flushed out without dismantling, the use of an immersion-type heater, changing the dimensions of the boiler or condenser, or increasing the capacity of the still by using a larger heater.

RALPH BROWN.

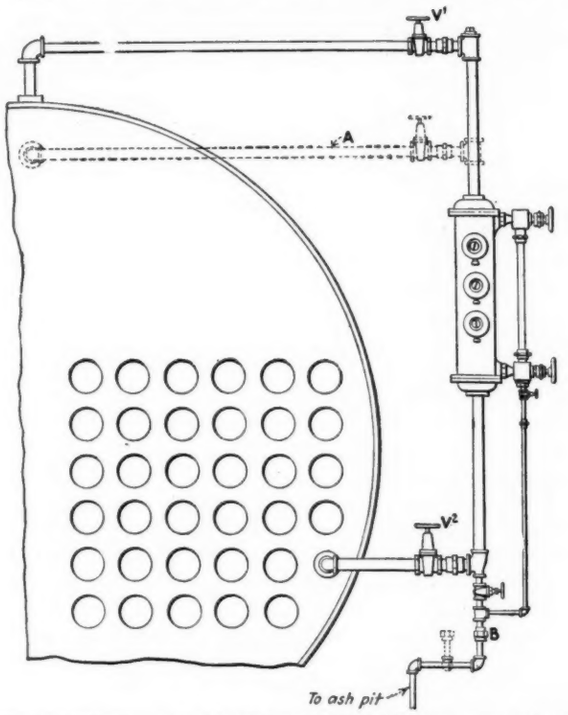
Belden, Calif.

Water-Column Connections and Blowdowns

Recent experiences have brought to my attention the fact that in installing water columns, caution is necessary in selecting pipe and fittings and also in placing them in position where they will be most serviceable. The top connection should never be in the smokebox, as brass pipe will eventually become thin when exposed to the heat and gases from the fire and is liable to give way. It should be connected to the top of the shell just back from the flange of the head. A piece of extra-heavy brass pipe was recently taken from the top connection of a water column, connected as shown at *A*. The pipe was originally 7/32 in. thick, but when removed it was found to be only ⅛ in. on the bottom side.

There has been much discussion about the use of valves V^1 and V^2 on water-column connections. In my opinion their only place is on a large marine boiler with several fireboxes where it is not convenient to shut the boiler down to make minor repairs to gage cocks or gage-glass valves, and where also there are usually two or more such columns on the boiler. In stationary service they are generally so scaled up that they leak every time it is necessary to close them. Then, owing to the possibility of some careless attendant forgetting to open one or the other of the valves, the insurance companies as well as boiler laws require them to be sealed open. When sealed open, the seal prevents the alternate method of blowing out the column connections. When valves are sealed, it should be the engineer's duty to make regular inspections and try the columns himself to make sure the connections are clear from scale. Crosses and plugs are often used in place of elbows and tees for the purpose of clearing the pipes, but on high-pressure boilers I consider it much better to disconnect the pipe than to risk breaking the cross or connections when attempting to remove the plugs.

The work of cleaning or inspecting column connections can often be simplified by using the proper valves and placing them in the right positions. If the usual small drain cock on the gage glass is replaced by a gate valve and drain pipe of reasonable size, the blowing down of the glass will be more effective; also in the



ARRANGEMENT OF COLUMN CONNECTIONS AND DRAINS

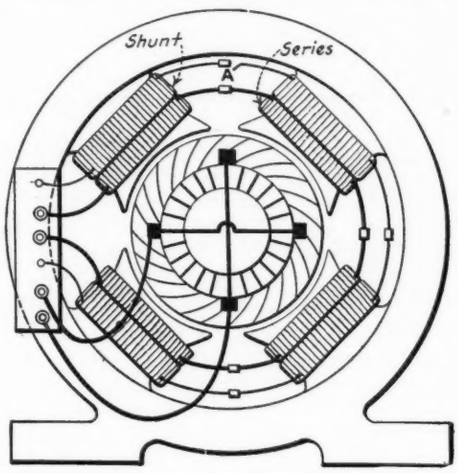
connecting of the drain pipe from the column to the ashpit, if an offset is put in the pipe as shown and a union placed on the vertical pipe as at *B*, the union can be disconnected and the pipe swung around out of the way, as shown by the dotted lines. A small rod can then be used to clear the vertical pipe. By arranging the connection and drain pipes in this manner, the crosses can be dispensed with and a much neater job of piping will result.

Cambridge, Mass. R. A. CULTRA.

Why the Exciter Failed

During the daily operation of a 2,300-volt alternator it was found necessary to exercise great care in the operation of the rheostats, especially that of the exciter. Cutting in all the resistance on this rheostat without cutting in the alternator's rheostat would not change the voltage of the main generator.

On several occasions when shutting down, the rheostats were turned down in a way that left the exciter



THE CONNECTION AT *A* HAD BURNED AWAY

demagnetized, making it necessary when starting up to take current from another machine to magnetize it again. On one occasion, however, the exciter could not be magnetized. Upon examining the machine, it was found that the connection at *A*, in the figure, had gradually burned away. This connection was resoldered and the machine was put back into service without the aid of magnetizing current from another machine, and no more trouble was experienced by the operation of the rheostats.

ARTHUR K. GENTZLER,
Burke Municipal Light and Power Plant.
Burke, S. D.

Using Gasoline Engines for Breakdown Service

The company I am connected with finds it necessary to rebuild the power plant, which is completely worn out. The engine is a high-speed unit some twenty years old; the boiler feed water is not good and the boiler scales badly; lack of water prevents condensing operation.

The problem confronting us is the question of the extent of the equipment to put in. Our load is approximately 150 hp. and it is exceedingly expensive to stop the manufacture of our products in event of power troubles, which have often occurred in the past. It is then advisable to have breakdown service. This, if secured from the central station, appears out of all proportion to the probability of needing it. It has been the intention to install two 150-hp. engines and two boilers of the same output. The cleaning of one boiler will be done while the second one is in service. Only one engine will be operated, the other one being used in case of breakdown.

Recently one of the firm has suggested that we put in only one engine and one boiler. Breakdown service, he suggests, could be obtained from a 150-hp. high-speed gasoline or kerosene engine-generator unit. By cleaning the boiler on Saturday or Sunday the gas engine need be used but once a week.

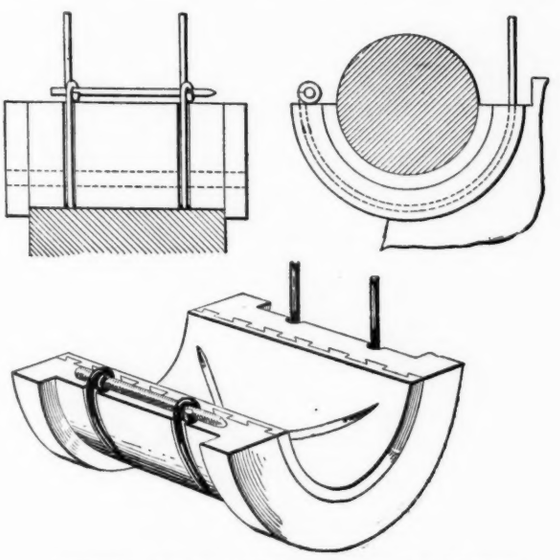
Since a steam engine and generator will cost, erected, around $30 per horsepower, and a second boiler would cost around $18 per hp., the second steam unit would cost with piping about $55 per hp. It is stated that an engine using kerosene or gasoline can be purchased for about $28 per hp., including the generator. If this unit uses a gallon of kerosene per 10 hp., or 15 gal. per hour at full load, the cost of operation per day of 10 hours would figure close to $15, using 10-cent kerosene. I am of the opinion that I should get a horsepower out of a good steam plant on 5 pounds of coal, which at $6 per ton means $2.25 per hour for 130 hp., or $22.50 per day. This would seem to prove that the kerosene engine should prove cheaper even for all-week operation. I would be glad to see some discussion as to the use of such high-speed gasoline or kerosene outfits for breakdown and constant-service conditions.

Jersey City, N. J. ANDREW BUSEK.

Rolling Out Main Bearings of Diesel Engines

Many Diesel engines are provided with lower main bearings of the type which is rolled out under the shaft in case of repair, and this removal is sometimes quite difficult, because of the inaccessibiiity of the bearings and the fact that the motion is of a rolling nature.

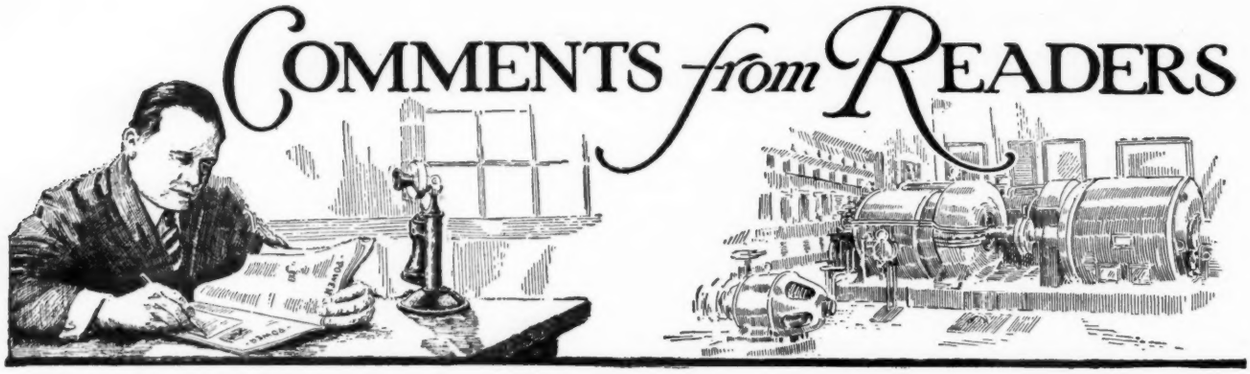
The illustration shows this type of bearing, together with a method of removal that has been found satis-



METHOD OF REMOVING DIESEL BEARINGS

factory. Grooves are turned in the lower shell as shown, thereby providing recesses for the insertion of wire cables. These cables are fastened together at one end by a pin, and the free ends are fastened to a small tackle. As the engine shaft is turned over, a small amount of force exerted on the cables will cause the shell to roll out from under the shaft. Little trouble has been found with this method, and the writer hopes it may be of some value to others. W. E. GREENE.

Buffalo, N. Y.



Why Do Piston Rings Break?

Referring to Mr. Airey's comment in the July 25 issue, on my letter in the June 6 issue, as to the breaking of piston rings, it would appear that my account was not as comprehensive as it might have been. I should have stated that the engine in question was less than a year old, and the ring breakages were common, almost from the start.

Even had it been an old engine and no caution had been used in the adjustment of the connecting-rod brasses, it could not possibly have lengthened the connecting-rod the nearly one-half inch that the ring projected over the counterbore, as the brasses would have been nearly worn through.

As to the weakening of the piston rod by altering the length of the key slot, the only part that could have been weakened, was the metal between the end of the slot and the end of the rod, and this metal is in shear. Enough only was cut off the end of the rod to clear the connecting-rod strap comfortably, leaving, as calculation showed, an abundance of metal to take care of the shearing stress.

Mr. Airey writes of "altering the standard length of the piston rod," but the second paragraph of my letter states that it was "due to an error in the builder's shop work," and it was so acknowledged by them.

Philadelphia, Pa. ALONZO G. COLLINS.

Filing Information

I wish to congratulate you on the Foreword in the June 27 issue, "Filing Information." You have treated the subject in an excellent manner, and I believe that it will be an incentive to more readers to clip and file the articles.

I have tried several methods of filing engineering information, including indexing on cards, which you have referred to, also binding the annual volumes and using the yearly index. Recently, I have adopted the system of clipping all articles that are of interest to me and filing them in a letter file. On this letter file I use the alphabetical arrangement under headings and, in addition, a series of numbers such as are obtained from the Cutter Tables that are used by librarians. By using a typewritten index with each serial number, I can take an issue of a technical paper, go through it and assign the index numbers, then at some leisure time, after possibly six months or a year, I remove the advertising pages and clip these articles.

There is a growing tendency among the various manufacturers to adopt the larger size of catalog so that it will readily fit in a letter file. I have received two or three late bulletins from manufacturing firms in which the outside cover can be made to take the place of the usual folder in a file, there being a suitable index provided at the top. CARL H. DUNLAP.

Chicago, Ill.

Commenting on the foreword in the June 27 issue on "Filing Information," I have tried different ways of filing or grouping articles but always experienced some inconvenience until I used my present method.

As I receive my various magazines, I place them on top of their respective piles on my desk until a convenient time, when I remove the covers and contents pages, then all advertising matter, and fasten the clips. I generally find the contents page sufficient, but I always place a sheet of commercial note paper next, on which I add notes when necessary. These I perforate and fasten together in the cover of the first issue of each volume. As each volume is completed, I perforate the reading material and fasten together, with contents, using strong twine.

I do not wish to create the impression that I do not care for the advertising matter. On the contrary, I take a great interest in it, as I am interested in the educational work of the N.A.S.E. I always keep several of the latest issues intact.

With regard to trade literature I believe that after a manufacturer goes to the expense of getting out descriptive matter he is desirous of distributing it to his advantage. Having seen in my twenty years' experience many a good piece of equipment either turned down altogether or installed and then condemned through lack of proper knowledge, I consider it is to the manufacturer's advantage to place some of his literature at the disposal of those who use the article. I further maintain that the man who looks through the advertisements and sends for trade literature, if of no benefit to the manufacturer at present, is one who is likely to be in the near future, either directly through advanced position or indirectly through advanced knowledge.

When I write a manufacturer for a bulletin, I always refer to the paper in which I saw the article advertised. I give my home address and state that I am not in the purchasing field, but wish the printed matter only for educational purposes, and I always acknowledge receipt.

In addition to printed matter, I frequently receive a letter offering further information if desired. I number each of the catalogues as received and keep them in numerical order on one shelf, but list them alphabetically in a small book, with the date received and number.

Brooklyn, N. Y. ALPHONSE C. IOOSS.

Automatic Stokers for Small Boiler Plants

Letters recently published in *Power* brought out the point that no arbitrary ruling could be made as to the minimum size of boiler under which automatic stokers could economically be installed, but that each case should be decided on its merits. The small-plant operator should not, however, make the mistake of allowing the stoker sales engineer to decide this question for him, because he will undoubtedly recommend the installation of stokers regardless of the size of boiler unit.

A good hand-fired dumping grate or semi-automatic stoker might do the work as economically at one-third the first cost.

When a boiler plant is made up of small horizontal return tubular boilers in sizes below 84 in. x 18 ft., or approximately 2,000 sq.ft. heating surface, the value of automatic stokers is, in my opinion, questionable, because the cost of installation per square foot of heating surface will be so high as to offset many of the advantages. Then, too, heavy overloads cannot be carried continuously, owing to limitation of the boilers, and consequently the full value of the stoker installation cannot be realized.

This point is well illustrated by the case of a plant addition built in 1916 and 1917, involving the installation of four 2,000-sq.ft. horizontal-return tubular boilers to burn low-grade anthracite. In the existing plant of fourteen similar boilers, hand-fired, it was not possible to develop continuously more than 70 per cent rating at an average efficiency of 50 per cent, so that some radical change in methods was necessary.

The approximate price for semi-automatic stokers for four boilers, installed complete with forced draft, including foundations, was $6,500; for automatic stokers, $17,000.

In view of the fact that the four boilers had been purchased for $13,600, the item of $17,000 for stokers seemed prohibitive and the semi-automatic stokers were installed with gratifying results in the way of labor saving, high efficiency and low maintenance. In short, the installation has done practically everything that could have been expected of an automatic stoker and at considerably less expense.

Another condition often unfavorable to stoker installations is found in the plant having one or two boilers operating for long periods under light load. In such a case the automatic stoker, if installed, should be of small size compared to the boiler, so as to operate efficiently at light loads, but as a matter of fact in the usual installation of this kind the stoker has been designed for some uncalled for overload and consequently operates for long periods at poor efficiency. Under such conditions a hand-fired grate can be temporarily bricked over to reduce the area and so render it possible to operate at good efficiency.

In the small plant stokers cannot as a rule reduce labor costs materially, and they will certainly increase maintenance and fixed cost, so that the saving, if any, must be in coal consumption; that is, increased boiler efficiency.

A very common error in this respect is to compare the best efficiency of the stoker with the poorest efficiency by hand firing. Why compare hand firing at 50 per cent efficiency with stoker firing at 70 per cent efficiency, when it is a known fact that by the expenditure of a few dollars in draft gages and the use of intelligent firing methods, a hand-fired boiler plant may be run at from 65 to 68 per cent, over-all efficiency, while a poorly operated stoker may often show only 50 to 60 per cent efficiency? It is the writer's personal opinion that in the average small plant stokers, when compared with hand firing on a fair basis, will not show more than 3 to 10 per cent fuel saving.

Considered as a means of obtaining needed capacity in an existing plant, without the installation of new boilers, automatic stokers often prove economical in the small plant, but even in such cases they must compete with the semi-automatic or hand-fired stoker.

Holyoke, Mass. A. S. WELLS.

When an Engineer Writes for Information

Regarding your timely foreword in the July 4 issue, I believe the best way for the engineer to save instruction booklets from a trip to the rubbish heap via the capacious waste basket of the purchasing department is to request that the information be mailed to his home address, whether he uses the firm's letterhead or the ordinary note paper.

"Store stationery" will usually get results if the writer states concisely where and how he is employed and why he desires the information. The following is a good sample of such a letter received by my company:

Dear Sirs:

I am an employee of the Adirondack Power and Light Corporation at South Amsterdam, N. Y., and operate condensers and pumps manufactured by you. I would like to ask you to send me the books on "The Care and Operation of Pumps and Condensers." As I am very much interested in your auxiliary equipment and would like to learn more about them, I would appreciate it very much if you would send me the booklets. Thanking you in advance, I remain,

Yours truly, ——— ———

JOHN F. GRACE.

Worthington Pump & Mchy. Corp

Arlington, N. J.

We are much interested in your foreword in the July 4 issue with reference to engineers who are sufficiently progressive to desire catalogs of power plant equipment.

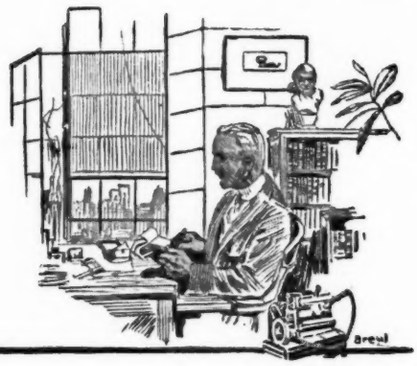
This company has always invited engineers to send for our printed matter, and we have made it a rule, not only to send such printed matter promptly, but to follow up the inquiry to learn if any further information is desired. We do this even though the inquiry comes on a postal card written with pencil, and without question as to why the information is desired.

We also spend a large amount of time and money each year in lectures with our glass boiler models before engineering associations, and in some cases incur an expense of one hundred dollars or more to demonstrate our apparatus before an association of perhaps thirty-five members.

We believe that the operating engineer is destined to decide which boiler is to be used in a large number of cases, and that his influence is becoming greater as time passes, so that anything we can do to bring the features of our boilers to the attention of engineers, and even firemen, will work to our mutual advantage in the future. We believe, however, that engineers, writing for expensive catalogs, should state the object of the inquiry, and acknowledge receipt of the printed matter promptly. E. KEELER COMPANY.

New York City.

QUESTIONS AND ANSWERS



Relative Capacities of 45-Deg. Bevel-Seat and Flat-Seat Safety Valves

What is the discharge capacity of a flat-seat safety valve as compared with a 45-deg. bevel-seat safety valve? M. A. S.

The discharge capacity of a flat-seat valve of a given diameter with a given lift may be obtained by multiplying the discharge capacity of a 45-deg. bevel-seat valve of the same diameter and same lift by $1\frac{4}{10}$.

Pressure Corresponding to Boiling Point

If at a certain place water boils at 202 deg. F., what would the barometer show the atmospheric pressure to be and about what would be the altitude of the place? W. G. P.

By reference to "Steam Tables," such as those of Marks and Davis, giving corresponding temperatures and pressures of steam below the pressure of the atmosphere, it may be seen that the pressure of 12.01 lb. per sq.in. absolute, or 24.45 in. of mercury-column pressure, corresponds with the temperature of 202 deg. F. of dry saturated steam. As the temperature of water at a boiling point is the same as the temperature of the dry saturated steam evaporated from the water, it follows that the atmospheric pressure, or barometer standing of 24.45 in., would exist for water to boil at the temperature of 202 deg. F. This barometric pressure corresponds with an altitude of about 5,400 ft. above sea level.

Percentage Weight of Air in Condenser

What is the percentage in weight of air in a condenser when the absolute pressure is 4 in. of mercury and the temperature of the air-vapor mixture is 103 deg. F.? W. L. R.

From the steam tables, the pressure of the vapor corresponding to 103 deg. F. is 2.107 in. of mercury. Hence the air pressure of the mixture=4—2.107=1.893 in. of mercury.

The density of steam at the stated temperature is given in steam tables as 0.003104 lb. per cu.ft.

The density of air at 0 deg. F. and standard barometric pressure (29.92 in. mercury pressure) is 0.08635 lb. per cu.ft., and therefore the weight of dry air per cu.ft. of the mixture is

$$0.08635 \times \frac{1.893}{29.93} \times \frac{460}{460 + 103} = 0.00446\ lb.$$

Hence the total weight of the mixture is

$$0.003104 + 0.00446 = 0.00755\ lb.\ per\ cu.ft.$$

and air in the mixture constitutes $\frac{0.00446}{0.00755} \times 100 = 59$ per cent of the total weight of moisture and air present.

M. E. P. for Equal Power from Opposite Ends of Cylinder

What m.e.p. would be necessary in each end of the cylinder of a 20 x 40-in. engine having a 3-in. diameter piston rod, running at 100 r.p.m. and developing 300 i.hp., one-half in each end of the cylinder? W. S. B.

The piston area acted upon by the steam pressure in the head end of the cylinder would be $20 \times 20 \times 0.7854 = 314$ sq.in., and the hp. = 150. By the usual formula,

$$hp. = \frac{P \times L \times A \times N}{33{,}000},\ 33{,}000 \times hp. = P \times L \times A \times N,\ \text{or}$$

$$P = \frac{33{,}000 \times hp.}{L \times A \times N}$$

As P = m.e.p., hp. = 150, L = 40 in. = 3.33 ft., A = 314.16 sq.in. and N = 100; then by substitution

$$m.e.p. = (33{,}000 \times 150) \div (3.33 \times 314.16 \times 100) = 47.31\ lb.\ m.e.p.$$

for the head end.

The cross-sectional area of the piston rod is $3 \times 3 \times 0.7854 = 7.0686$ sq.in., and the net area of piston acted upon by the steam pressure in the crank end of the cylinder would be $314.16 - 7.0686 = 307.0914$ sq.in. Substituting as before, but with this value for A, gives

$$m.e.p. = (33{,}000 \times 150) \div (3.33 \times 307.0914 \times 100) = 48.41\ lb.\ m.e.p.$$

for the crank end.

An Examination Question

The following question was asked on an examination for stationary engineers:

"2. (10) What should be the ratio of the diameter of the air cylinder to that of the steam cylinder, in order to compress air to 100 lb. per sq.in., when the steam pressure of the boiler plant is 75 lb. per sq.in.? Assume the efficiency of the compressor as 80 per cent."

How would this be answered, assuming the candidate is not allowed the use of textbooks or tables during the examination? H. P.

The question involves (1) the mean effective pressure that would be obtained in the air cylinder, which would depend on the percentage of clearance, and (2) the mean effective pressure required in the steam cylinder, which would depend on the steam pressure, point of cutoff, percentage of cylinder clearance and the back pressure of the exhaust.

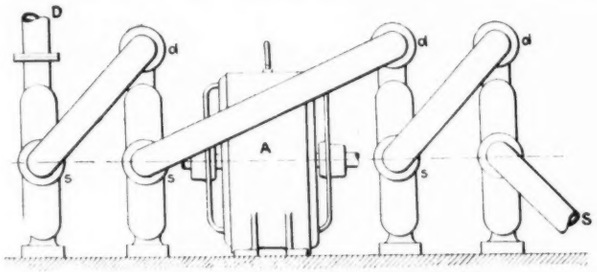
The question, as stated, does not give the necessary data; therefore the relative sizes of cylinders cannot be computed. But even though these data that are omitted were to be given, solution of the question would involve the employment of a table or a slide rule giving hyperbolic logarithms, which no one should be expected to carry in his head.

Unless the data necessary for computing the answer are to be obtained from some other part of the examination papers or questions, it is but reasonable to suppose that only an offhand answer is expected, based on general knowledge of air-compressor dimensions. For the steam and air pressures and efficiency named in the question, compressor manufacturers generally supply steam and air cylinders of the same diameter; that is, 1 to 1.

High Lifts with Centrifugals in Series

For raising water with centrifugal pumps, where a single pump cannot raise the water to a sufficient height, cannot several centrifugals be employed in series? P. H.

The required energy may be imparted to the water by means of two or more moderately sized pumps



CENTRIFUGAL PUMPS IN SERIES

arranged in series in place of a single pump of large diameter running at a high velocity. High lifts frequently have been accomplished in this manner, using a pair of centrifugals driven direct by a double-cylinder steam engine or other motor. The figure is a sketch diagram representing an arrangement of four centrifugals as coupled by a European maker to an electric motor *A* with all mounted on the same bedplate.

Water received at the main suction *S* of the first centrifugal is successively delivered by the delivery outlets *d* and suctions *s* to the fourth centrifugal with the discharge *D*. It is stated that a plant of this kind was employed to raise water through a height of more than 150 feet.

Simple Tests of Mineral Oils

What simple engine-room tests can be made for determining the quality of engine and machine oils? R. N. C.

For determining whether an oil is well refined, fill a clean bottle about half full of the oil and heat slowly over an open flame, until vapor appears above the oil surface, and maintain that temperature for 15 minutes. If well refined, the oil will darken in color, but will remain perfectly clear and free from sediment after standing for 24 hours; but if the oil has been poorly refined, it will turn black and, after standing, a black deposit will appear.

To test for tarry and other residues, place a small quantity of the oil in a test tube along with about 20 times the quantity of 85 Bé. gasoline. Allow the mixture to stand for an hour, and the tar and other insoluble matter present will collect at the bottom of the test tube.

A well-refined oil should show no trace of sulphuric acid. A simple test for acid is made by partly immersing a piece of highly polished copper in the oil for about 24 hours. If a trace of acid is present, the immersed surface of the polished copper will be made dull. The simplest test for sulphuric acid is to wash a sample of the oil thoroughly with warm water and test the water with neutral litmus paper. If even a faint reddish tint is shown on the paper, the oil should be rejected.

A quick method of detecting the presence of animal oils is to place a few drops of the oil sample in the palm of one hand and rub it briskly with the other hand. The heat produced will cause the animal oil, if present, to emit its characteristic odor. A rough test to determine the presence of animal oils in compounds with mineral oils may be made by heating two ounces of the oil in a small glass or test tube with the same quantity of borax, caustic potash or caustic soda, for about 15 minutes, when the presence of animal oil will be shown by a light-yellow deposit.

Order of Firing in Multi-Cylinder Gas and Oil Engines

What are the usual orders of firing in oil and gas engines having more than one cylinder? W. T. S.

In Fig. 1 are shown the more common arrangements of cranks in two-stroke cycle engines having three to eight cylinders.

In the column at the right of the figure are given the orders of firing for corresponding crank arrangements.

The orders of firing in four-stroke cycle engines ap-

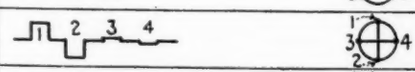
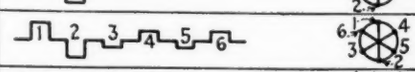
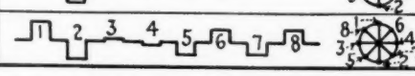
Number of Cylinders	Arrangement of Cranks	Order of Firing
3		123
4		1423
6		145236
8		16472538

FIG. 1. ORDER OF FIRING IN TWO-STROKE-CYCLE ENGINES

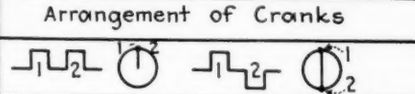
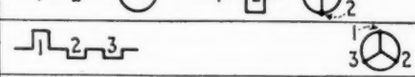
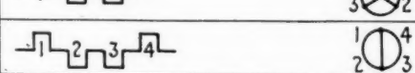
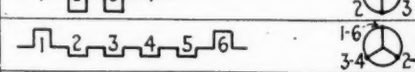
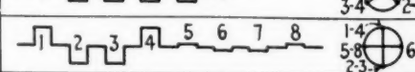
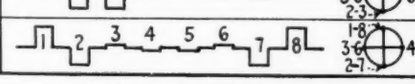
Number of Cylinders	Arrangement of Cranks	Order of Firing
2		12 12
3		132
4		1243
6		153624
8		16284735
8		15268473

FIG. 2. ORDER OF FIRING IN FOUR-STROKE-CYCLE ENGINES

pearing in Fig. 2 are given for the crank arrangement of engines having from two to eight cylinders. It will be noted that the eight-cylinder unit may use either of two arrangements.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Permanent Pyrometer Systems*

By R. G. FELGER

IN MODERN boiler plants the greatest loss at the present time is the heat in the wet flue gases which pass out the chimney. A rough estimation of the heat loss in the flues gases of the Connors Creek Plant of the Detroit Edison Co. amounted to 19.35 per cent of the total heat input. The average daily consumption of coal during 1921 was 1,195 tons. If the cost of coal had been $6 per ton, the daily loss would have been $1,398 or $510,000 per year.

It is true that the temperature of the outgoing gases can be decreased by the addition of economizers, or a change in the baffling may materially reduce the temperature, but these changes cost money, and the economy depends upon the cost of the coal. If by careful firing and with clean boiler surfaces the flue gases can be reduced 50 deg., a saving of $47,000 is realized in a year of such operation, and this gain is worth striving for.

Many boiler plants are equipped with CO_2 recorders of various designs, and these instruments certainly aid the firemen in boiler operation. The same is true of draft gages and steam-flow meters, but not much has been done with permanent pyrometer systems installed for operating purposes.

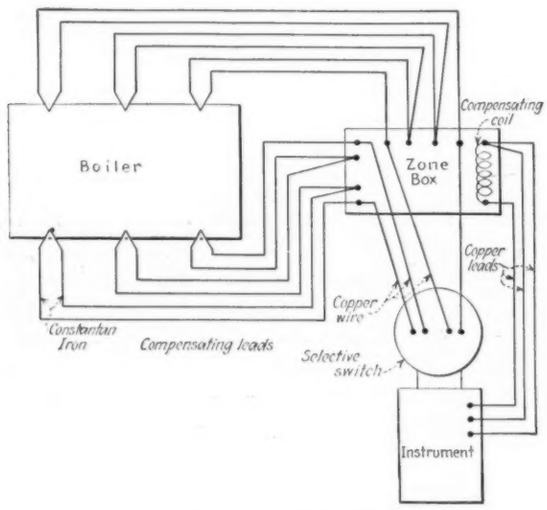


DIAGRAM OF PYROMETER INSTALLATION

This installation consists of a potentiometer system as applied to a "W" type boiler; it gives the average temperature of three thermocouples connected in series and of each side of the boiler separately.

The Detroit Edison Co. has been experimenting with various pyrometer systems for a number of years, and at the present time two systems are in use; one the nitrogen gas-filled tube and the other the iron-constantan thermocouple, using the potentiometer for the indicating instrument. The latter has given better satisfaction, and this system has been adopted in most of the plants.

Since there is only one installation of the nitrogen bulb system in the company's plants and preliminary experiments are just being made, not much information can be given on this system. Much trouble has been experienced with leakage, and there is a lag of at least six minutes.

Selection of Thermocouples

Almost any two dissimilar metals may be used as thermocouples. Certain combinations are unsatisfactory, however, because of the small electromotive force that can be developed and because of the fact that with some combinations the electromotive force is so variable that it changes direction as the temperature increases. Obviously desirable features and properties of thermocouples are: Ability to resist corrosion and oxidation, development of relatively large electromotive force, a temperature-electromotive-force relation such that the latter increases continuously with increasing temperature over the range to be employed, ability to maintain its calibration for a long period of time, homogeneity of the wire, low initial cost to install the system and low maintenance cost.

The iron-constantan wire was selected by this company because, with few precautions, all of these factors are obtained in boiler work. The wire is obtained in coils and made into couples as required. Corrosion or oxidation has never been encountered in the eight years this type of couple has been used. The electromotive force developed is not the greatest to be obtained, but it is large enough to give temperatures with an error of less than 1 per cent. The temperature-electromotive-force relation is nearly a straight line and can be used safely as such for short ranges in temperature. In tests that have been made the couples have maintained their calibration during six years of continuous operation. If the proper insulators and protecting tubes are used, there is no danger of contamination of the wire.

Making Up Couples

The proper mounting and protection of a couple is of great importance. The hot junction of the couple is made by fusing the two wires in an arc or oxygen flame. Insulating tubes are slipped over the wires to keep them separated and insulated from each other. There are many kinds of insulating tubes on the market, but the ordinary lava tubes are satisfactory for boiler work. These tubes are not expensive and can be purchased from almost any pyrometer firm. The couples are placed inside of a piece of wrought-iron pipe and the terminals of the couple are fastened to ordinary posts mounted on a conduit head on the pipe. The end of the pipe near the hot junction should be capped or plugged. Galvanized pipe cannot be used because the zinc will attack the constantan wire and contaminate it.

Indicating Instruments

In commercial work, galvanometers or millivoltmeters are generally used to indicate the temperature to be determined. There are many objections to the use of galvanometers. When operated at usual temperatures in boiler work, the base metal couples develop less than 25 millivolts. A very sensitive millivoltmeter is therefore required. On the other hand, the instrument must be able to withstand rough handling, and these opposing conditions are hard to satisfy. Besides this, the instrument must have a high resistance so as to make any change in resistance of the thermo-electric circuit negligible as compared with the total. Durable indicators are obtainable, having resistances of 300 to 1,200 ohms, which operate fairly well in certain industries; but the scale of the switchboard type of instrument must be confined, resulting in limitations of the accuracy. Other limitations are lack of proper cold-end compensation devices and the difficulty of keeping in adjustment. The advantage claimed for the instruments of this type is the low initial cost. It is true that the instrument can be purchased at a lower cost, but for a complete system the special wires and equipment necessary to properly compensate for the cold-end temperature brings the cost far above instruments of a more accurate and durable type.

According to the Bureau of Standards, the potentiometer is the most accurate instrument for measuring the electromotive force of a thermocouple. The electromotive force of the thermocouple is measured by opposing to it a known electromotive force, a galvanometer being used merely as a current detector to show when no current is flowing—that is, when the balance in electromotive forces is complete. Since the galvanometer is always used as a zero instrument in a strictly potentiometer circuit, it requires

*From the report of the Station Operating Committee, National District Heating Association Cedar Point, Ohio, June 20-23, 1922.

no calibrated scale, and no attention need be given to the constancy of its sensitivity, provided it is always sufficiently sensitive to serve its purpose. The potentiometer is graduated to read either in millivolts or temperatures directly, if the current is always adjusted to a definite value.

The potentiometer method has several advantages. The scale is easily made open, thus permitting accurate readings; the calibration of the scale is in no way dependent upon the constancy of magnets, springs, jewels, nor upon the level of the instrument. The entire potentiometer, including battery, standard cell, slide-wires, etc., is mounted in a case not much larger than that of a millivoltmeter and will stand much rougher handling than most instruments of this type. From a pyrometric standpoint, the greatest advantage is the elimination of errors due to changes in the resistance of the couples or the lead wires. No matter what resistance is inserted in the circuit, the readings on the potentiometer will still be true electromotive force. The only objections to the potentiometer are its slightly higher initial cost and the fact that usually a manual adjustment is made. The greater initial cost is overcome by the ease with which the cold-junction compensation can be obtained without the necessity of additional equipment of excessive cost.

Potentiometers used by the Detroit company, especially in permanent installations, are wired with additional resistance to make them balance with large thermocouple electromotive forces; that is, such as obtained with three thermocouples in series. The cold-junction compensation coil is outside of the instrument and operates automatically. Potentiometers of this type may be obtained in the form of recorders in which all of the various manipulations are performed mechanically, even the balancing against the standard cell, and they are remarkably accurate.

In the Congress Street plant of the company, the pyrometer installation consists of a potentiometer system, giving the average temperature of three thermocouples connected in series, the thermocouples being located in different points in the same cross-section of the uptake just below the damper. Since the boilers are of the "W" type, two sets of couples are used in each boiler, giving the temperature of each side separately, as shown in the accompanying diagram.

The cold-junctions are brought to a common central point with the compensating coil in the same box; thus the minimum amount of compensating wire is used. The instrument is an indicating, hand-operated potentiometer of the gage-board type. A selective twelve-point contact switch is used (since there are twelve different sets of couples) to connect the various series of couples to the instrument. The operation is simple and the temperature is read directly. The firemen have been instructed so that everyone is able to obtain the temperature readings for himself. This system has proven satisfactory and good operating results have been obtained.

The advantage of the recording potentiometer is the continuous temperature chart. The system may be equipped with a selective switch and operated the same as the installation just described, but this company has equipped a number of the larger boilers with an individual system. The instruments are made with strip charts, but circular charts have been adapted to them. Experiments are now being made on the circular recorder, having a dotted line for one side of the "W" type boilers and a dashed line for the other; but this has proven unsatisfactory, since at times the lines cross, confusing the operator.

Tests of long duration have proven that the accuracy of the instrument cannot be improved, and as a laboratory instrument it is ideal; but some minor changes must still be made before the recording potentiometer will become a practical boiler-room instrument.

N.A.S.E. National Convention To Be Held in Des Moines

For the first time Des Moines, Iowa, is to have the annual convention of the National Association of Stationary Engineers. Preparations are well under way for a record-breaking gathering. The program calls for a number of papers and welfare talks, so that education as well as routine business will be the order of the day. The exhibitors are coming in fast, and it is anticipated that the full available space will be occupied by the time the convention is called to order on Sept. 11. Headquarters will be at the Hotel Savery, while the exhibits and sessions of the convention will be held under one roof in the Coliseum, four blocks distant. The convention committee consists of C. A. Bland, chairman; A. T. Luce, secretary; J. M. Furlong, treasurer; J. J. Wagner, J. A. Murphy, L. T. Hazelwood and E. Bailey. The program in detail follows:

Monday, Sept. 11, the local reception committee will meet all trains and escort arrivals to hotels and the Coliseum, where official registration will take place from 9 a.m. to 9 p.m. At 8 p.m. the mechanical exposition will be officially opened. Clyde A. Bland, chairman of the local convention committee, will preside. There will be addresses by Frank Martin, president of the National Exhibitors' Association; Henry Adams, president of the Des Moines Chamber of Commerce; H. D. Campbell, president of the Des Moines Manufacturers' Association, and Richard W. Parry, national president of the Association. At 9 p.m. a band concert in the Coliseum will follow the addresses and plans have been made for an informal reception at 10 p.m. to officers, delegates and visitors at Hotel Savery, followed by dancing.

CONVENTION COMMITTEE OF DES MOINES. STANDING, LEFT TO RIGHT: A. T. LUCE, JOHN A. MURPHY, E. BAILEY, JAMES M. FURLONG; SITTING: J. J. WAGNER, CLYDE A. BLAND, L. T. HAZELWOOD

Tuesday, Sept. 12, at 10 a.m., those attending the convention will parade from hotel headquarters to the Coliseum for the opening session of the convention, at which Clyde A. Bland will preside. The program calls for addresses of welcome by Gov. Nate Kendall, Mayor Carl Garver, and George Hamilton, in behalf of the Chamber of Commerce. In respective order the responses will be made by National President Richard W. Parry; National Vice-President Frederick Felderman and Alfred Johnson, past national president. After the preliminary addresses President Parry will officially open the convention and appoint the usual committees. The official convention photograph will be taken at 1 p.m. on the river bank beside the Coliseum. At 1:30 p.m. the first business session will be convened to hear reports of officers and committees.

At 3 p.m. there will be a technical paper on "Recent Developments in Feed Water Treatment," by F. L. Dunham, of Chicago. The Life and Accident Department will hold its annual meeting at 4 p.m. An interesting program is being arranged.

Wednesday, Sept. 13, 9 a.m., is the time set for the second business session of the convention at which there will be reports of committees, Board of Arbitration, Trustees of Protection Fund, and the Trustees of the *National Engineer*. At 10:30 a.m. Charles H. Bromley is scheduled to deliver a welfare paper on "Causes of and Remedies for Dry Rot in Associations," on which discussion by delegates is solicited. The afternoon will be devoted to the Field Day exercises consisting of the usual games, base ball, etc., to be held at the State Fair Grounds. At 8 p.m. the National Exhibitors' Association will entertain in the Coliseum, the occasion being their annual spread to the delegates.

Thursday, Sept. 14, 9 a.m., the routine business session will be followed by a technical paper to be announced later. At 11:15 a.m. the National Ladies Auxiliary will pay their official visit to the convention. Following will be the annual memorial services to the memory of departed members. At 1:30 p.m., there will be another business session and at 2:30 p.m. a welfare paper on "The Power Plant Engineer As a Specialist—Is It Being Overdone?" by John W. Lane. Thursday evening, 10 p.m., is the time set for the opening of the official grand ball.

Friday, Sept. 15, 9 a.m., a business session of the convention will be followed by election of officers, selection of the 1923 convention city, payment of mileage and installation of officers. At 4 p.m. the Board of Directors will hold its annual meeting.

Minority Would Accept Ford's Muscle Shoals Offer

"The heavy losses to the Government that have piled up at Muscle Shoals since the armistice, now amounting to about $3,000,000, should be stopped, and the quickest way to stop these losses is to accept Henry Ford's offer for the purchase and lease of the Government Muscle Shoals property." Such is the conviction of those senators forming the minority group in the Senate Committee on Agriculture, as expressed in the report submitted by Senator Ladd on August 4. For purposes of comparison a statement of twelve parallel provisions of the respective bills, proposing operation under Ford's plan and under government ownership, forms the main body of the report. The Ford offer is next summarized under twelve headings, and then follows the opinion of the minority with regard to the advantages which would accrue if the offer were accepted:

First, our national defense would be greatly strengthened through the provision of a supply of the nitrate indispensable in the manufacture of explosives. Under the terms of his offer Mr. Ford would be bound to maintain Nitrate Plant No. 2 for 100 years, in an up-to-date and efficient condition, ready for immediate use in time of war. This means that he must carry on a program of continuous research to determine the most improved methods for the operation of such a nitrate plant.

Second, the cost of fertilizer to the farmer could be reduced through the application of existing commercial processes at Muscle Shoals. Nitrogen, cheaply produced, is one of the necessary elements in cheap fertilizer, and it is felt that under the Ford plan fertilizer could be produced at Muscle Shoals which would be able to successfully compete with that produced in Chile.

Third, development of water power at Muscle Shoals by Ford would result in the introduction of a plan of water-power development that would ultimately make hydro-electric power in the United States as cheap as in more naturally favored countries such as Canada and Norway. Since a hydro-electric plant costs a great deal to construct and but little to operate, the single item of interest on the original investment may constitute 80 per cent or more of the power cost. Mr. Ford proposes to eliminate the interest charge by amortizing and returning the investment, through the operation of a long-time sinking fund. This would eliminate capital charges and interest and would ultimately reduce the cost of power generation to the mere cost of operation, maintenance, replacement, taxes and administration, which in a large plant is from $2 to $5 per hp. per year, or less than one mill per kilowatt-hour. Thus the bonded indebtedness of the Muscle Shoals plant would be reduced, instead of being increased as is frequently the case in refinancing operation.

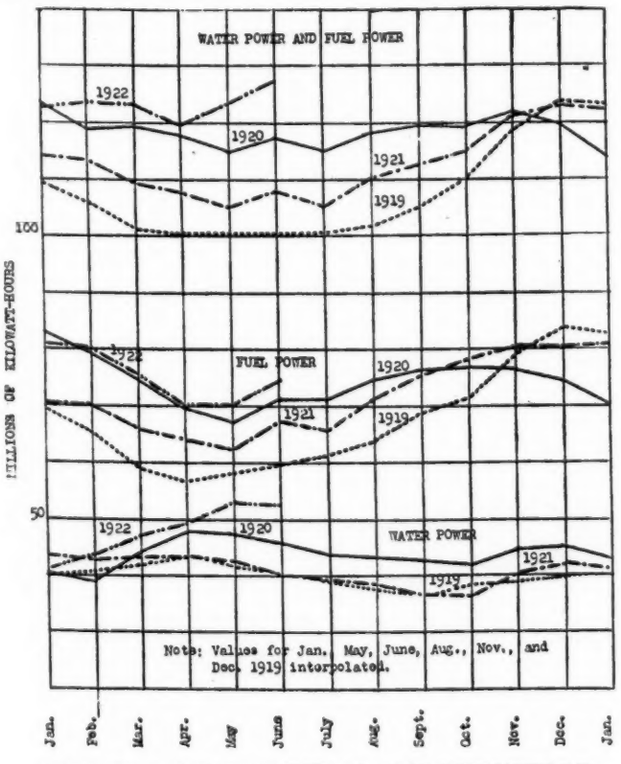
Fourth, the Tennessee River would be made navigable under the Ford plan, thereby providing an outlet by water for a section of the country having a great variety of useful raw materials.

The minority group of senators state that they wish it clearly understood, at the very outset, that they do not claim that the Ford offer is without objections; indeed, they state that certain objections to the Ford offer seem apparent, but they insist nevertheless that none of the objections to the Ford offer can be remedied or solved by government ownership and operation at Muscle Shoals. They express the fear that if the Ford offer is rejected, the losses at Muscle Shoals resulting from wasteful operation will continue as an ever-increasing burden on the taxpayers of the land.

Electrical Output in the United States Reaches New High Mark

A new record in the production of electric power by public utilities was reached in June, when the daily average was 128,000,000 kw.-hr. The highest previous daily average output was 124,000,000 kw.-hr., in December, 1919. These figures represent total power produced, both water and fuel power. Of the June output of 3,831,500,000 kw.-hr., water power figures as 41.4 per cent.

The curves shown are those of the latest report of the United States Geological Survey. The fact that the curve representing total output has pointed steadily upward since April and has reached an unprecedented figure for this time of the year, shows beyond doubt that industry is getting up speed for a real return to prosperity, with no sign of a let-down ahead.



AVERAGE DAILY PRODUCTION OF ELECTRICITY BY PUBLIC-UTILITY PLANTS IN UNITED STATES, 1919-22

News in the Field of Power

Make Greater Use of Engineering Societies' Employment Service

An employment service for engineers of every variety of training and experience has been conducted for some time by the four national engineering societies. This service brings in touch with the various business men the service of 50,000 trained technical men who are members of these societies and one of the objects of it is to show to the various commercial houses the aid which engineers are rendering to others in the same lines and to help these firms and corporations secure similar assistance. Men of engineering training are prominent in all branches of commercial endeavor, and their creative ability is recognized as being of great help in the building up of the nation's wealth.

This service is in a position to supply the readers of *Power* with chemical engineers, civil engineers, mechanical engineers, electrical engineers, sales engineers, production managers, superintendents and other trained executives, and is under the direction of Mr. W. V. Brown, in the United Engineering Building, No. 29 West 39th St., New York City. It is free to both employer and employee.

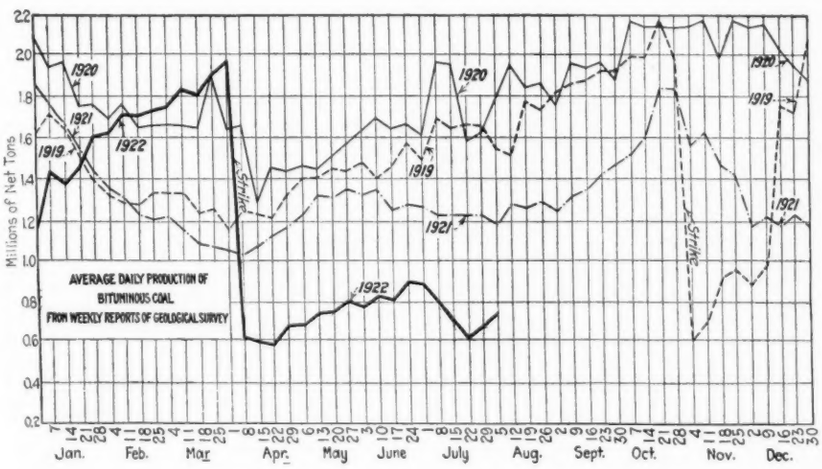
Advocates Court of Conciliation for Industrial Disputes

A method of settling future industrial disputes affecting the operation of interstate commerce is contained in a bill introduced in the Senate by Senator Spencer of Missouri. The senator would create a Federal Court of Conciliation composed of three judges appointed by the President, confirmed by the Senate and having the same qualifications and powers as district judges.

The bill proposes that the court of conciliation meet at any place in the United States convenient to the case in hand, and that it have the same power as existing federal courts to enforce its decisions. Its jurisdiction would be confined, however, to disputes endangering the general public welfare and would begin only after efforts to settle the controversy by the usual methods of conference or voluntary arbitration had failed. After abiding by the court's order for thirty days, either party to the dispute would have power to request the court to modify or reverse its order. Such requests the court would be bound to consider. Further appeal to the Circuit Courts of Appeal and to the Supreme Court is provided for in the bill. Special stipulation is made that "no order, judgment, or decree shall require any individual man to work except when and where and under such conditions as he pleases."

Coal Production Curve Takes Upward Turn

Improved transportation conditions in the Middle Appalachian fields resulted in a slightly increased bituminous output during the eighteenth week of the coal strike, July 31-Aug. 5. According to the weekly coal bulletin of the United States Geological Survey, however, the mines that responded to the President's invitation to resume production had little to do with this increase.



The curve reproduced on this page shows that since July 22 there has been a fairly steady increase. Preliminary returns indicate a production of 4,250,000 tons of soft coal during the eighteenth week, against 3,933,000 tons in the week before. However, in spite of this increase production is still about 1,100,000 tons short of the maximum reached just before the railroad shopmen's strike, in the week ending June 24, when 5,337,000 tons were raised.

In the strongly organized districts there has been practically no increase in output, and shipments from Pennsylvania and from the Fairmont and Kanawha districts show no perceptible gain.

Fewer Engineers Out of Work

Technical men are in demand in nearly all the basic industries, while the demand for architectural and structural draftsmen with building or plant experience has far exceeded the supply, according to a report issued by the employment department of the American Association of Engineers.

The report states that the building industry has been most active, with highway and municipal work coming next. Employers in both these fields find it difficult to obtain experienced men. With the regard to geographical differences, the report continues as follows:

Employment conditions for engineers in most territories are normal or very nearly so. The Southwest reports a scarcity of mechanical and structural men. California reports that students for summer employment are the only men available. Missouri reports normal conditions with calls for structural engineers predominating. Employers in Eastern cities, where more men are usually available, are experiencing difficulty in finding capable engineers, with the possible exception of the District of Columbia.

The total number of positions being received by the American Association of Engineers is over 400 each month, with about 250 of these filled by the Association. This large placement is due to concerted local activity by capable employment representatives. The average monthly salary of all positions filled during June was $192. A number of positions above the $500 mark were filled.

While the general conditions are better at this time than they have been for over two years, there is still some irregularity, but the main trend shows improvement supported by prospects of further gain. Added reasons for more hopeful feeling appear in the continued increase in the operation of the iron and steel industry, the diminishing of unemployment of skilled and unskilled labor and the active progress of building operation.

Interborough Subway Power Plants Operate Efficiently

In an effort to clear itself of certain charges made in the press, to the effect that its power stations were being operated wastefully and inefficiently, the Interborough Rapid Transit Co., New York, has made the following statement in its monthly bulletin:

In order that the reader may be in a position to judge for himself as to the efficiency of our power stations, it may be stated that at the Seventy-fourth Street Station the average number of B.t.u. used to produce a kilowatt-hour for the past three months has been 22,645, and during the month

of May only 22,291 per kilowatt-hour were required as compared with 22,500, which has been quoted as a reasonable standard of efficient performance. This performance for the month of May is within 2½ per cent of the best performance ever recorded for the station, which was in the month of February, 1916. Of course it is impossible to maintain this extremely high efficiency uniformly at all times, but the record of these recent months proves conclusively that there has been no decline in the operating efficiency of the Seventy-fourth Street Station since the days when it was a model for the entire country.

Americans Take Part in Brazilian Engineering Congress

The engineering societies of America will participate in the International Engineering Congress to be held in Rio de Janeiro, Brazil, Sept. 7-30, in conjunction with the Brazilian Exposition. Two joint committees, made up of members of the A.S.M.E., A.S.C.E., A.I.E.E. and A.I.M. & M.E. have been formed, one to act in this country and another composed of members residing in Brazil. The first committee is as follows:

A.S.M.E.: Dwight P. Robinson, Percy H. Thomas, C. H. Crawford, Maurice Coster and Calvin W. Rice.

A.I.E.E.: F. L. Hutchinson, Maurice Coster and Percy H. Thomas.

A.S.C.E.: J. W. McConnell, Fred Lavis, Verne L. Havens, Milton H. Freeman and John H. Dunlap.

A.I.M. & M.E.: F. Linwood Garrison, George W. Tower and F. F. Sharpless.

On the first, or American committee, Percy H. Thomas has been elected chairman, Ernest Hartford secretary and Verne L. Havens (editor of *Ingeniería Internacional*), chairman *pro tem.* C. H. Crawford will be chairman of the second, or Brazilian committee, and will appoint the other members.

Fuel Committee to Take Care of New York State Utilities

In order to keep account of the fuel needs of all electric railway, gas, electric, water and steam utilities in New York State, and to see that coal is obtained by those utilities which must have it if they are to maintain service, an Utilities Fuel Committee was formed on Aug. 5.

This commmittee is composed of executives of public utility companies in all parts of the state. It will act in conjunction with the Governor's fuel commission. John W. Lieb has been made chairman and C. H. B. Chapin, secretary.

Obituary

Frank Toomey, Sr., died in Scranton, Pa., on August 2, at the age of 72. Mr. Toomey was the retired president of Frank Toomey, Inc., 127 North Third St., Philadelphia. He was born in Liverpool of Irish-English parentage, came to this country when a young man, became connected with the Baxter Engine Co., of Hartford, Conn., and handled its products for many years in the eastern part of the United States. His business was founded in 1876 under his own name and incorporated in 1909. In 1916 he retired from the presidency, being succeeded by his son, Frank Toomey, Jr.

Mr. Toomey, Sr., was well known throughout the East and in Canada as a man of remarkable vision, kindly and cheerful disposition, and the possessor of a wonderful memory for details.

Coming Conventions

National Safety Council, 168 N. Michigan Ave., Chicago, Ill. Eleventh Annual Safety Congress, Detroit, Aug. 28-Sept. 1.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Des Moines, Ia., Sept. 11-16. Annual conventions and exhibitions of the State Associations scheduled as follows:

Iowa, at Des Moines, Sept. 10-11; Abner Davis, Room 16, Waterhouse Block, Cedar Rapids, Iowa.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention and exhibition at Minneapolis, Minn., Sept. 11.

Association of Iron and Steel Electrical Engineers, 1007 Empire Bldg., Pittsburgh, Pa. Annual convention and exhibition at Cleveland, Ohio, Sept. 11-16.

New England Water Works Association, Boston. Annual convention at New Bedford, Mass., Sept. 12-15.

Business Items

The Dearborn Chemical Co. has appointed George R. Stege as successor to Frank Eardley, recently deceased manager of stationary sales at the company's branch office in the Frisco Bldg., St. Louis.

The Bundy Steam Trap Co. has appointed W. W. Booth and F. M. Malany as its representatives in the New York territory, with headquarters at Room 901, 26 Cortland St., New York City.

The Detroit Stoker Co., Detroit, Mich., has found it necessary to acquire a larger plant in which to manufacture Detroit Underfeed and Detroit "V-type" Stokers. The company has purchased the plant at Monroe, Mich., formerly occupied by the Van Blerck Motor Co. The head office of the company will remain in the General Motors Bldg., Detroit.

The New Brunswick Iron Works, New Brunswick, N. J., has assumed ownership and control of the Worthington Water Tube Boiler Co., formerly owned and controlled by Messrs. James Beggs and Co., New York City. General sales offices of the New Brunswick Iron Works are at 145 W. 38th St., New York City. Manufacture of the Worthington Sectional Water Tube Boiler will be continued by the new owners.

Trade Catalogs

Steam Traps—Bundy Steam Trap Co., Nashua, N. H. A 58-page bulletin, descriptive of the company's new line of steam traps. Individual parts of each type are illustrated and listed. Tables of dimensions and instructions for installation and adjustment are given.

Safety Water Columns, Steam Traps, etc.—The Reliance Gage Column Co., 5902 Carnegie Ave., Cleveland, Ohio. A 16-page catalog describing principally the company's safety water columns for steam boilers, designed to give low-water alarm or both low- and high-water alarm. Tables of sizes and prices for the different types are given, as well as instructions for installations and care. The provision of the A. S. M. E. Boiler Code relative to water columns is given in condensed form, and on the last two pages are some tables of practical value. The Reliance Steam Traps and Seamless Copper Floats are also described.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	July 31, 1922	Aug 7, 1922
Pool 1,	New York	.....	.....
Smokeless,	Columbus	$7.50–8.75	$3.50–7.00
Clearfield,	Boston	5.50–6.50	6.25–7.50
Somerset,	Boston	5.50–6.50	6.25–7.50
Kanawha,	Columbus	7.00–8.50	3.50–7.50
Hocking,	Columbus	7.00–8.50	3.50–7.50
Pittsburgh No. 8	Cleveland	8.00–9.00	7.75–8.00
Franklin, Ill.,	Chicago	.....	.....
Central, Ill.,	Chicago	.....	.....
Ind. 4th Vein,	Chicago	.....	.....
West Ky.,	Louisville	7.00–7.50	3.50–9.00
Big Seam,	Birmingham	4.00–5.00	2.20–4.25
S. E. Ky.,	Louisville	7.00–8.50	3.50–8.00

FUEL OIL

New York—Aug. 10, Port Arthur light oil 22@25 deg. Baumé 4c. per gal.; 30@35 deg., 5c. per gal. f.o.b. Bayonne, N. J.

Chicago—Aug. 7, for 24@26 deg. Baumé, $1.15 per bbl.; 21@36 deg., 3½c. per gal. in tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Aug. 9, f.o.b. refinery, Pennsylvania, 36@40 deg., 5c.; Kentucky fuel oil, 26@30 deg., 3¾c. per gal.; Gas oil, 32@34 deg., 2¾c. per gal.; 36@38 deg., 3c.; 38@40 deg. 3¼c. Western, 24@30 deg., $1.05@$1.10 per bbl.

Philadelphia—Aug. 7, 26@28 deg. Baumé, Oklahoma, 80@90c. per bbl.; 30@34 deg., Oklahoma (group 3), 2⅝@2¾c. per gal.; 16@20 deg. Seaboard, $1.35@$1.50 per bbl.

Cincinnati—Aug. 8, for 26@28 deg. Baumé, 5¼c.; Diesel, 28@30 deg. 5½c. per gal.; distillate 38@40 deg., 6c.

Cleveland—Aug. 8, 26@28 deg. Baumé, 4¼c. per gal.

New Plant Construction

PROPOSED WORK

Ariz., Superior—The Magma Copper Co. plans to build a large smelting plant. Estimated cost $500,000. Architect not announced.

Cal., Fresno—The Green Mill Amusement Park is having plans prepared for an amusement park on highway outside the city limits, including 125 x 250 ft. main building, ice cooling and steam heating systems and latest revolutionary type of indirect lighting.. Company will also build ice cooling and ice making plant and large swimming tank. Bids will be asked about Aug.. 20. Estimated cost. $350,000. Ellery, Frost & Patten, 1913 Fresno St., Engrs.

Cal., Oakland—The Bd. Educ. will receive bids until Sept. 11 for a 2 and 3 story high school on 19th Ave. and East 18th St. Estimated cost $700,000. C. W. Dickey, 2149 Bway, Archt. Noted July 18.

Cal., San Francisco—The City and County of San Francisco will soon receive bids for furnishing and delivering street car motor equipment under Sect. C, Contr. No. 132; also for furnishing and delivering street car aid brake equipment Contr. 132.

Cal., Santa Rosa—The city received following bids Aug. 1 for extending water system: Butte Electric Constr. Co., 534 Folsom St., San Francisco, air lift for artesian well, rein.-con. aerator, flume, receiving reservoir, compressors, motors, crane, pipe, meters, electrical machinery, etc., and using two 5 in. Byron-Jackson centrifugal pumps, $46,000, using two 6 in. Byron-Jackson pumps, $45,645, Worthington pumps, $46,672, using two 5 in. Worthington single stage pumps, $46,114, Courtenay pumps, $45,630. G. H. Chick, R.F. D. 1, Box 143, Napa, all works using Worthington 11 x 7 x 12 2 stage compressors, Venturi meters, General Electric or Electric Controller Manufacturing Company's switchboards, Byron Jackson 5 in. centrifugal pumps, c.i. pipe, etc., all work cost plus 10% with a bonus for savings under total cost of $45,250 (total cost not to exceed $50,000 for completed project). Fairbanks-Morse Co., 651 Mission St., San Francisco, two 400 volt, 60 cycle induction motors, 60 hp. with base, 10½ pulley, $536 each, taking both motors, $1,126; two 400 volt, 50 hp., 1,200 r.p.m. motors, without base or pulley, $482 each, both motors, $984. Gardner Air Compressor Co., 505 Howard St., San Francisco, two 12 x 6 x 12 horizontal two stage air compressor, f.o.b. Santa Rosa, $2,502 each, with short belt add $84 each, if sub-base not required deduct $100 each; two 4 x 9 x 10 compressors, 350 cu.ft. per min., at 200 r.p.m., 125 lb. pressure, $2,211 each, with short belt add $65 each, if sub-base not required deduct $100 each. Allis-Chalmers Co., Rialto Bldg., San Francisco, two 5 in. A. C. horizontal split case centrifugal pumps, base plates, etc., $1,054; two 50 hp., 3 phase, 60 cycle motors, $574; two starters complete, 50 hp. motors, $168; two 60 hp., 60 cycle motors, $1,281; two starters for 60 hp. motors, $183; alternative, two 60 hp., 50 deg. instead of 40 deg. $1,050; two starters, all f.o.b. Santa Rosa, $231. Proctor Co., Spring St., furnishing all pipe, valves and fittings, including one 14 in. duplex Venturi meter, etc., $6,450. Natl. Meter Co., Premier water meters, etc., $800, Sullivan Mchy. Co., Hobart Bldg., San Francisco, two 12 x 7½ x 10 two stage air compressors, $3,430. Worthington Pump Co., f.o.b. Santa Rosa, two 6 in. 2 stage centrifugal pumps, $1,890; two 5 in. single stage centrifugal pumps, $1,170; two compressors, 13 x 8 x 10, duplex, belt driven, unloaders, idlers, etc., $4,170, deduct for loaders, idlers, $110; alternative, two 11 x 7 x 12 two stage compressors, $4,198, deduct for loaders, idlers, $110. Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco, (f.o.b. San Francisco) two 4 in. stand pumps, horizontal double suction, $1,200; Herzog Electric Co., 172 Stewart St., San Francisco, (f.o.b. Santa Rosa) 2 centrifugal pumps, 850 g.p.m.., $421 each, two 50 hp. motors, $835 each, two 6 in. pumps, 1,150 g.p.m., $685 each, two 50 hp. motors, complete, $1,221 each. Manistee Iron Wks., Rialto Bldg., San Francisco, two centrifugal pumps and motors, $2,880, two compressors, motors, etc., $4,500. Ingersoll-Rand Co., Rialto Bldg., San Francisco, 2 Imperial type compressors, $4,578.

D. C., Wash.—The Dept. of Agriculture, E. K. Parks, Engr., will receive bids until Aug. 18 for the construction of a refrigeration plant.

Ia., Cedar Rapids—The Bd. of Educ., J. A. Motejl, Secy., 705 1st Ave., will soon receive bids for a 3 story, 160 x 200 ft. Junior high school, including a steam heating system. Estimated cost, $475,000. B. Rugh, 811 Security Bldg., Archt. Frank Tustison Co., 322 Auditorium Bldg., Minneapolis, Minn., Engrs.

Ind., Plymouth—The Bd. Educ. will soon award the contract for a 2 story, 163 x 179 ft. high school. Estimated cost $300,000. E. Young, South Bend, Archt.

Ind., Terre Haute—J. D. Palmer & Co. Archts., McKeen Natl. Bank, is preparing plans for a 6 story store and hotel building. Estimated cost $1,000,000. Owner's name withheld.

Ind., Terre Haute—The Wabash Apartment Co., c/o J. D. Palmer & Co., Archts., McKeen Natl. Bank, plans to build a 4 story, 82 x 140 ft. apartment building. Estimated cost $400,000.

Kan., Atchinson—E.. Brielmaier & Sons Co., Archts., 432 Bway., Milwaukee, will receive bids until about Aug. 20 for a 4 story academy building for the Mt. Scholastica Academy, 8th and Ecclier Sts. Estimated cost $500,000. Noted Mar. 14.

Kan., Atchison—The Henry Weis Manufacturing Co., 1014 Commercial St., is in the market for a 1 hp., 3 phase, 60 cycle, 220 volt engine.

Kan., Wichita—The Weaver Ice & Cold Storage Co., W. Weaver, Purch. Agt., 752 South Hydraulic Ave., is in the market for a d.c. 110 or 120 volt generator, not less than 3 kw. nor over 5 kw. (New or used).

Kan., Wichita — The Wichita Water Works Co., J. C. President, Purch. Agt., 211 North Market St., will expend $100,000 for waterworks and is in the market for pump.

La., Lockport—The Barrios Motors, c/o F. C. Barrios, plans the construction of an electric plant, here.

Md., Annapolis—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for additions to refrigerating plant at the Naval Academy Hospital, here, from the Clothel Refrigerating Co., 61 Bway., New York, (1) $1,950 (30 days), (2) $1,880 (30 days), (3) $160; Chatard & Morris, 304 Continental Bldg., Baltimore, (1) $2,050, (2) $2,050, (3) $256; York Mfg. Co., York, Pa., (1) $2,075 (50 days), (2) $2,020 (50 days), (3) $290.

Mass., Fall River—The School Board is having plans prepared for a 3 story high school in North Park District. Estimated cost $400,000. N. S. Chase, 583 Center St., Archt., R. C. Sturgis, 100 Boylston St., Boston, Assoc. Archt.

Mass., Worcester—The School Comn. will receive bids until Aug. 23 for 3 story, 181 x 268 ft. junior high school, including steam heating and ventilating systems, on Grafton and Dorchester Sts. Estimated cost $700,000. J. D. Leland Co., 41 Mt. Vernon St., Boston, Archts. Noted Nov. 15.

Minn., Minneapolis—W. Guttman, 558 8th Ave. N., is in the market for a refrigerating machine for proposed 1 story, 26 x 60 ft. creamery.

Minn., St. Paul—The Dept. of Educ., L. R. S. Ferguson, Comr., City Hall, is having revised plans prepared for a 3 story, 150 x 250 ft. Junior high school, with 48 x 90 ft. wing, including steam heating system, on Isabel and Congress Sts. Estimated cost, $325,000. F. Lewes, City Hall, Archt. Noted June 20.

Minn., St. Paul—The Tilden Produce Co., W. A. Tilden, Pres., 65 East 3rd St., is in the market for creamery and refrigerating machinery.

N. J., Princeton—The Princeton Inn Co., C. Browner, Pres., plans to build a hotel on Alexander St. Estimated cost $350,000. Engineer not selected.

N. Y., Binghamton—The Binghamton Light, Heat & Power Co., 172 Washington St., has purchased the Rockbottom Dam, here, and plans extensive improvements, enlarging same to furnish power to the city industries.

N. Y., Binghamton—The city plans to purchase chain of small lakes in Chemung County and develop same to adequately furnish the city with new water supply, including filter stations, pumps, piping etc. Estimated cost of developement, not including purchase of lakes, $200,000 to $300,000. Engineer not announced.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, is having plans prepared for a high school on Classon Ave. and Eastern Parkway. Estimated cost $450,000. C. B. J. Snyder, Concord St., Archt. and Engr.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York is having sketches prepared for P. S. No. 177 on Avenue P. and Dahill Rd. Estimated cost $500,000. C. B. J. Snyder, Concord St., Archt. and Engr.

N. Y., Gerry—The Niagara, Lockport & Ontario Power Co., Marine Bank Bldg., Buffalo, plans the construction of an electric plant, here. Estimated cost $15,000. Engineer not announced.

N. Y., Jamestown—The Niagara, Lockport & Ontario Power Co., 294 Hinman Rd., Lockport, plans improvements and construction of new transmission lines as follows: about 20 mi. of insulation lines from Athol Springs to Dunkirk, about 50 mi. of double circuit transmission lines from Dunkirk to Falconer and about 30 mi. of extension to retail distributing service from Athol Springs to Westfield. Estimated cost $942,626. Engineering Dept., c/o owner, Engrs.

N. Y., Jamestown—The Western New York Electric Co., 316 North Main St., plans to increase capacity of Washington St. substation; build transformer and frequency station at Falconer (suburb of Jamestown) and high powered insulation lines for extension of service throughout Chautauqua County. Estimated cost $453,886. Engineering Dept., c/o owner, Engrs.

N. Y., New York—The Bd. Educ., 500 Park Ave., will receive bids until Aug. 22 for an addition to the Julia Richman High School, including steam heating system, at 67th and 68th Sts. near 2nd Ave. Estimated cost, $1,750,000. C. B. J. Snyder, Concord St., Brooklyn, Archt. and Engr.

N. Y., New York—The Bd. Educ., 500 Park Ave., is having plans prepared for a 5 story school, including steam heating system, at 126 East 105th St. Estimated cost $625,000. C. B. J. Snyder, Concord St., Brooklyn, Archt. and Engr.

N. Y., New York—The Dept. Parks, F. D. Gallatin, Pres., Municipal Bldg., will receive bids until Aug. 17 for furnishing and erecting an ice making plant in the American Museum of Natural History, 77th St. and Central Park West. Noted June 13.

N. Y., Niagara Falls—The City plans to enlarge its filter plant from present capacity of 15,000,000 gals. to 32,000,000 gals. Estimated cost, $300,000. W. B. Bennett, City Engr.

N. Y., Pittsford—R. M. Newcomb, 25 Main St., is in the market for a large electric light plant for use in lighting buildings in farm section.

N. C., Charlotte—The City Comrs. will receive bids until Aug. 29 for a complete plant for water supply system of about 10,000,000 gal. daily capacity, including filter house, pump reservoir, storage and settling basins, mixing house and chemical house with laboratories. Estimated cost $400,000. W. M. Piatt, Durham, Engr.

Ohio, Canton—The First Natl. Bank will receive bids until Aug. 22 for a 14 story, 85 x 87 ft. bank and office building, including a steam heating system, on Market and Tuscarawas Sts. Estimated cost, $400,000. F. L. Packard, Hayden Bldg., Columbus, Archt.

Ohio, Cleveland—Halle Bros. Dept. Store, S. P. Halle, Pres., Euclid Ave. and Huron Rd., plans to build an annex on Huron Rd. Estimated cost $400,000. Walker & Weeks, 1900 Euclid Ave., Archts.

Ohio, Hicksville—The Bd. Educ, H. O Beltz, Clk, Mark Center, will receive bids until Aug 17 for constructing an electric light and power line for the Mark Twp. high school at intersection of Mark, Farmer and Hicksville Rds., Mark Twp.

Ohio, Lima — The Lima Locomotive Works, South Main St., are in the market for machinery and equipment for a superheating plant.

Ohio, Shakers Heights—The Bd. of Educ., J. W. Main, Clk., has had plans prepared for a 3 story high school on Onaway Rd. Estimated cost $600,000. C. W. Bates, Wheeling, W. Va., Archt.

Ohio, Warren—General Fire Extinguisher Co., N. A. Neracher, Vice Pres., has had plans prepared for a 4 story, 80 x 200 ft. factory. Estimated cost $300,000. G. S. Rider & Co., Century Bldg., Cleveland, Archts.

Pa., Allentown—The Bd. of Dirs of the Lehigh Valley Transit Co., 802 Hamilton Ave., has authorized building a bathhouse with swimming pool, including pumps and filtering system. Estimated cost $150,000. A. F. Smith, 14th and Gordon Sts., Engr.

Pa., Altoona—The Bd. Educ. will soon award the contract for a 3 story, 224 x 232 ft. Junior high school on 6th Ave. and 15th St. Estimated cost $880,000. J. Millard, Hutchinson Bldg., Archt.

Pa., Carbondale—A. Jacobson, South Main St., plans to build a 4 story, ultimately 8 story, store and office building on Church St. Architect not announced. Total estimated cost, $500,000.

Pa., Neville Island—Petri Glazo, Inc., c/o E. V. Reed, is having plans prepared for a 1 story, 75 x 140 ft. brick manufacturing plant. A 150 hp. boiler and 50 hp. slide valves will be installed. Private plans.

Pa., Phila.—The city will soon receive bids for a reduction plant. Estimated cost $500,000. F. A. Dunlop, City Hall, Engr. Private plans.

Pa., Pittsburgh—The Duquesne University, Bluff St., and A. F. Link, Archt., 407 North Craig St., are receiving bids for a 3 story school, gymnasium and power house. Estimated cost $150,000.

Pa., Pittsburg—The Treas. Dept., J. A. Wetmore, Superv. Archt., Wash., D. C., plans the construction of a U. S. Veterans Hospital on the Hall Property at Aspinwall. Estimated cost $1,000,000.

Pa., Williamsport—The Clinton Natural Gas & Oil Co., c/o D. D. Kline, Secy., plans to drill ten wells for oil and gas in the Kettle Creek Field, near here, and is in the market for pumping equipment. Estimated cost $25,000.

S. D., Salem—The city plans the construction of a filtration plant. Estimated cost $15,000. Chenoweth & Rettinghouse, 210 Boyce-Greeley Bldg., Sioux Falls, Engrs.

Tenn., Nashville—M. McKissack, Archt., 331½ Cedar St., will soon receive bids for a 4 story publishing and office building, at 4th and Cedar Sts., for the National Baptist Sunday School Bd. Estimated cost $250,000. Separate bids will be received for plumbing, heating, lighting and construction.

Tex., Breckenridge—The Dillingham Ice Cream Co. is in the market for machinery and equipment for proposed ice manufacturing plant, 65 ton capacity.

Va., Ashland—The Ashland Ice Co., C. S. Boochen, Purch. Agt., is in the market for a 3 ft. fan for cooling tower.

Va., Richmond—Acca Temple, A. O. N. O. M. S., c/o C. L. Williams, will soon receive bids for a 5 story temple on Main and Laurel Sts. Estimated cost $1,000,000. M. E. Wright, American Natl. Bank Bldg., Archt.

Wis., Clinton Junction—The City, c/o C. B. Commons, is having plans prepared for enlarging well for water purposes, and installing new air lift.

Wis., Delavan—The State Bd. of Control, Capitol Bldg., Madison, plans to install cooling apparatus and system at the State School for Deaf here. Engineer not selected.

Wis., Green Bay—The State Bd. of Control, M. J. Tappins, Secy., Capitol Bldg., Madison, will receive bids until Aug. 22 for steam heating, ventilating and plumbing systems, including boilers, for the State Reformatory, here.

Wis., Milwaukee—Milwaukee Elks Lodge, 448 Jefferson St., has had new plans prepared and will soon receive bids for a 9 story, 110 x 145 ft. club house on Mason and Marshall Sts. Estimated cost $1,200,000. R. A. Messmer & Bro., 221 Grand Ave., Archts.

Wis., Milwaukee—S. E. Tate Printing Co., 133 2nd St., is having preliminary plans prepared for a 6 story, 60 x 120 ft. printing plant and office building on Bway. M. Tullgren & Sons, 425 East Water St., Archts.

Ont., Port Credit—The town, G. W. Gordon, Clk., will receive bids until Aug. 21 for building pumping station, reservoir, settling basin, filters, supplying and erecting overhead steel tank, centrifugal pumps, valves, about 2 mi. of 4, 6 and 8 in. c.i. pipe, meters, etc., for waterworks system. Estimated cost $60,000. Gore, Nasmith & Storrie, 625 Confederation Life Bldg., Toronto, Engrs. Noted Apr. 25.

Ont., Saulte Ste. Marie—The Algoma Steel Corp., 503 Queen St. E., plans to build a 1 story heat treatment building for the treating of splice bars. Estimated cost $50,000.

India, Bombay—Valabhdas Runchordas & Co., 70 Apollo St., is in the market for dynamo for copper plating, 3 volts, 150, 250 and 340 amps. respectively, for nickel plating, 6 volts, 50, 100, 150 and 250 amps. respectively; one 5 B.H.P. engine, capable of using crude or refined oil, for copper and nickel plating dynamo; one 45 B.H.P. oil engine as above to drive hydraulic pump for accumulator, etc., having pressure of 1 ton per sq. in.; one horizontal compound steam engine, suitable for maximum load of 45 B. H. P., complete, with suitable boiler and fittings, 150 lb. steam pressure and taking up smallest amount of floor space; one small boiler about 3 N.H.P., say 6 ft. x 2 ft. 6 in. diameter; electric motors, 1 to 10 hp. to drive small machinery, such as lathes, band saws, planing machines, etc.

CONTRACTS AWARDED

Cal., Richardson Springs, (Los Angeles P. O.)—Richardson Bros. will build a 5 story hotel. Estimated cost $200,000. Work will be done by day labor.

Cal., Turlock—The Hunt-Jewett-Bontz Co. has awarded the contract for a 4 story alcohol and vinegar plant on South 1st St., to the Oscar Krenz Copper & Brass Works, 812 Bryant St., San Francisco. Estimated cost $180,000. The company is in the market for about $275,000 worth of machinery and equipment.

Fla., Miami—The City Council has awarded the contract for sanitary and storm sewerage systems, including sump and 2 centrifugal pumps, each 2,000,000 gal. per day capacity and 50,000 gal. storage tank, to J. J. Quinn Co., Miami, $53,722. Noted July 18.

Ill., Urbana—The University of Illinois, c/o J. M. White, Superv. Archt., 256 Administration Bldg., has awarded the contract for an agricultural building to H. B. Krauel, Danville, $354,700.

Neb., Lincoln—The State Capitol Comn. has awarded the contract for constructing the superstructure for the first section of the Capitol, Trades Nos. 1 to 26, to J. H. Wiese Co., 1425 W. O. W. Bldg., Omaha, $1,356,185.03, who sublet Trade 23, heating, ventilating, plumbing and associated work to the Robert Parks Plumbing & Heating Co., 711 South 16th St., Omaha, $213,647.

N. H., Bennington—The Monadnock Paper Mills have awarded the contract for a dam to the Aberthaw Construction Co., 27 School St., Boston, Mass. Estimated cost, $50,000.

N. J., Nutley—Bd. of Educ. has awarded the contract for a high school, including a steam heating system, to the Morgan Constr. Co., 207 Market St., Newark. Estimated cost $300,000. Noted Dec. 20.

N. J., Trenton—The City Commission has awarded the contract for 30 in. class B pipe, with new pumping equipment, 11 lengths, to the U. S. Cast Iron Pipe & Fdry. Co., Morris Bldg., Phila., Pa. $6,785.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, has awarded the contract for P. S. No. 161, on Crown St., to Frymier & Hanna, 25 West 45 St., New York, $594,000, P. S. No. 189, on East New York Ave., to T. A. Clarke Co., 122 Livingston St., $573,000. Noted May 23.

N. Y., Buffalo—Clement & Weed, c/o N. P. Clement, 80 Genesee St., have awarded the contract for a 14 story office building at Main and Genesee Sts., including razing the present building, to the Turner Construction Co., 242 Madison Ave., New York City.

N. Y., New York—The 2069 Broadway Corp., c/o G. F. Pelham, Archt., 200 West 72d St., will build a 9 story, 50 x 102 ft. apartment building at 17 East 84th St. Estimated cost $300,000. Work will be done by day labor. Noted July 25.

N. Y., Wende—Bd. of Supervisors of Erie Co., Buffalo, has awarded the general contract for the construction of penitentiary buildings, here, to Morris & Allen, Inc., Prudential Bldg., Buffalo, $682,031; heating and ventilating, to Power Efficiency Corp., White Bldg., Buffalo, $47,000; electrical work, to Robertson Electric Co., 151 West Mohawk St., $9,798.

N. C., Belhaven—The town has awarded the contract for furnishing and installing a 200 hp. Fairbanks-Morse semi-diesel oil engine with General Electric generator and switchboard, in the proposed addition to electric light plant, to J. R. Proctor, Bayonne, N. J., $17,432. Noted July 4.

N. C., Pilot Mountain—The town has awarded the contract for a dam and power house on the Ararat River here, to M. E. Jones, Granite Falls. Noted Oct. 25, 1921.

Ohio, Cleveland—The Western Reserve University, S. S. Wilson, Secy., has awarded the contract for a medical school, animal house and power house, on Cummington Rd., to Lundoff-Bicknell Co., 5716 Euclid Ave. Estimated cost $2,500,000. Complete power plant equipment will be installed.

Ohio, Lima—The Lima Locomotive Wks. has awarded the contract for 5 additions to its plant, to J. Stewart & Co., 30 Church St., New York City. Estimated cost $1,500,000.

Pa., Ardmore—The School Board, c/o A. Hamilton, has awarded the contract for a 2 story high school, to F. M. Harriss & Co., 1520 Parish St., Phila., $446,482. Noted May 2.

Pa., Bellevue—The Duquesne Light Co., 435 6th Ave., Pittsburgh, has awarded the contract for a 4,000 kw. substation, ultimate capacity 8,000 kw., on Maryland and Forrest Sts., to D. P. Robinson Co., 125 East 46th St., New York City. Estimated cost $300,000.

Pa., Phila.—The Philadelphia Tract Society, 17th and Arch St., has awarded the contract for a 4 story, 40 x 115 ft. office building at 1707 Arch St., to Cramp & Co., Denckla Bldg. Estimated cost $150,000. A steam heating system will be installed.

Pa., Pittsburgh—The Duquesne Light Co., 435 6th Ave., has awarded the contract for an 8,000 kw. substation, ultimate capacity 16,000 kw., on Sandusky and North Diamond Sts., to the D. P. Robinson Co., 125 East 46th St., New York City. Estimated cost $300,000.

Pa., Pittsburgh—The Exchange Natl. Bank, 240 5th Ave., has awarded the contract for a 7 story, 40 x 120 ft. bank and office building, to S. M. Siesel 105 Wells Ave., Milwaukee, Wis. Estimated cost $350,000.

Pa., Wilkinsburg—The Duquesne Light Co., 435 6th Ave., Pittsburgh, has awarded the contract for an 8,000 kw. substation, including switches and circuit controlling apparatus to enable handling about 25,000 kw. in and out, on Penn and Swissvale Sts., to the D. P. Robinson Co., 125 East 46th St., New York City. Estimated cost $300,000.

R. I., Newport—The Newport Hospital has awarded the contract for replacing 2 H. R. T. boilers, installing piping, etc., in proposed addition to boiler house, to the International Engineering Works, Inc., 1029 B. T. Bldg., Boston, Mass.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., has awarded the contract for coal and ash handling equipment at the U. S. Naval Base, here, to the Wilbur G. Hudson Corp., 50 Church St., New York, $47,700. Noted Aug. 8.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., has awarded the contract for a heating plant at the U. S. Naval Base, here, to the American Bridge Co., Wilkins Bldg., Wash., D. C., $24,707. Noted Aug. 8.

W. Va., Wheeling—The State Road Dept., has awarded the contract for 10 air compressors for use in the extensive road building program now under way, to the Novo Engine Co., 702 Porter St., Lansing, Mich.

Wis., Milwaukee—The Edward Motor Car Co., 2713 Grand Ave., has awarded the contract for a 2 story, 108 x 200 ft. garage on 36th St. and Grand Ave., to the Coddington Engineering Corp., 290 3rd St. Estimated cost $100,000. A compressor and motors will be installed.

Wis., Two Rivers—The City has awarded the contract for intake crib, suction well and suction pipe line, to McMullen & Pitz, 915 Commercial St., Manitowoc.

Ont., Toronto—The Hydro Electric Comn., University Ave., has awarded the contract for a 2 story, 47 x 64 ft. substation for supplying power for the Toronto Transportation System at the Eglington Ave. car barns, to Witchall & Son, 156 St. Helens Ave., $42,000. Switchboards, step down transformers, oil switches and lightning arresters to cost about $50,000 will be installed.

Ont., Fort William—The Fort William Paper Co. has awarded the contract for 10 centrifugal pumps, capacity 1,000 to 5,000 gal. per min., against 60 to 120 ft. heads, to the Northern Foundry & Machine Co., Saulte Ste. Marie. Estimated cost $25,000.

Ont., Port Arthur—Provincial Paper Mills, Ltd., awarded contract for 14 centrifugal pumps up to 6 million gal. per day.